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MULTIPLE-AIRCRAFT INSTANTANEOUS LINE SOURCE (MAILS) DISPERSION MODEL USER'S GUIDE

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This report is a user's guide for the Multiple-Aircraft Instantaneous Line Source (MAILS) atmospheric dispersion model. MAILS is an interactive air quality model containing an integrated database of aircraft engine air pollutant emissions. The intended application of the MAILS model is the prediction of ground-level air pollutant concentrations from low-altitude (less than 3000 feet above ground-level) military aircraft operations along military training routes.

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EXECUTIVE SUMMARY

This document serves as a user's guide for the Multiple Aircraft Instantaneous Line Source (MAILS) atmospheric dispersion model computer software. MAILS is an air quality screening model that provides conservative estimates of ground-level pollutant concentrations resulting from aircraft engine emissions along low-altitude (under 3000 ft) military training routes (MTRs).

The MAILS model was developed to evaluate the air quality impacts of proposed MTRs, in accordance with the environmental impact analysis requirements of the National Environmental Policy Act of 1969 (NEPA, Public Law 91-190) and AFR 19-2, USAF Environmental Impact Analysis Process. Previous analyses indicated that the air quality impacts of low-flying aircraft were potentially significant with respect to Prevention of Significant Deterioration (PSD) Class I pollutant increments (applicable primarily in certain national parks and wilderness areas) and were insignificant with respect to National Ambient Air Quality Standards and PSD Class II increments.

Existing air quality models were deemed inadequate for application to the instantaneous line source emissions produced by intermittent aircraft flights along MTRs. Therefore, the MAILS model was created for this unique type of pollutant source. The model was integrated with an aircraft engine emissions database to produce an interactive, user-friendly modeling system.

Validation of the MAILS model using actual ground-level concentration measurements was not feasible, because of the lack of appropriate measurements and the technical difficulties in obtaining them. Therefore, a performance evaluation of MAILS was accomplished by comparing MAILS results with manually-averaged results obtained from an existing, validated, atmospheric dispersion model developed by the U.S. Environmental Protection Agency (EPA). The MAILS model test results were in very close agreement with the EPA model test results.

The MAILS output provides estimates of air pollutant concentrations from proposed MTRs and comparisons of the concentrations with existing PSD Class I increments. The MAILS model can be run quickly and requires minimal user

training to execute and to interpret or apply results. The model is recommended as a planning and assessment tool for those involved in the environmental impact analysis process for proposed and/or existing low-altitude military airspaces. An explanation of modeling techniques used to calculate pollutant concentrations is usually required in environmental impact assessments and statements. A summary describing the MAILS model, suitable for attachment to such documents, is included as an appendix to this report.

PREFACE

This report was prepared by the Oak Ridge National Laboratory, P. O. Box 2008, Oak Ridge, Tennessee 37831, under an Interagency Agreement (IAG) between the U.S. Department of Energy (DOE) and the Department of the Air Force (DOE IAG No. 1489-1489-A2, USAF No. F88-52), for the Air Force Engineering and Services Center (AFESC), Engineering and Services Laboratory, Tyndall Air Force Base, Florida.

This report summarizes work done between July 1988 and February 1990. Captain W. P. Chepren and Captain M. T. Moss were the AFESC/RDVS Project Officers.

This version of the MAILS software, Version 3.0, includes more general menu drivers than previous versions. Version 3.0 and the description herein supersedes all previous versions.

This report has been reviewed by the Public Affairs Office and is releasable to the National Technical Information Services (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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LIST OF ABBREVIATIONS AND ACRONYMS

CAA	Clean Air Act
CFR	Code of Federal Regulations
CO	carbon monoxide
EPA	U.S. Environmental Protection Agency
GEIS	Generic Environmental Impact Statement
HC	hydrocarbons
ISCST	Industrial Source Complex, Short-Term (model)
MAILS	Multiple-Aircraft Instantaneous Line Source (model)
MOA	military operations area
MTR	military training route
NAAQS	National Ambient Air Quality Standards
NO_2	nitrogen dioxide
PART	particulate matter
PC	personal computer
PM-10	particulate matter under 10 microns in diameter
PSD	Prevention of Significant Deterioration (of air quality)
RA	restricted area
SAILS	Single-Aircraft Instantaneous Line Source (model)
SO_2	sulfur dioxide
USAF	U.S. Air Force

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SECTION I

INTRODUCTION

A. OBJECTIVE

This report provides instructions for the use of the Multiple-Aircraft Instantaneous Line Source (MAILS) atmospheric dispersion model. MAILS is intended as a screening model for prediction of air quality impacts of air pollution emissions from low-flying aircraft on military training routes (MTRs). An air quality screening model is generally defined as one that provides worst-case concentration estimates and can be run quickly with a minimum of user input. The MAILS model predictions of pollutant concentrations are considered to be worst-case estimates because of the assumptions incorporated in the model design.

B. BACKGROUND

The impetus for development of MAILS was the need to address the air quality impacts of low-altitude MTRs as part of the environmental assessment process required under the National Environmental Policy Act of 1969 (NEPA, Pub. L. 91-190). In accordance with NEPA, the U.S. Air Force (USAF) has begun preparation of a Generic Environmental Impact Statement (GEIS) addressing the impacts of establishing new low-altitude military airspaces. Potential air quality impacts were assessed for the preliminary draft GEIS in part using the Single-Aircraft Instantaneous Line Source (SAILS) dispersion model (Reference 1). The SAILS model was later modified by integrating an aircraft emissions database and adding the capability for multiple-aircraft assessment in a single model run. The modified model was named MAILS.

An important finding from the modeling analysis conducted for the GEIS was that the air quality impacts of low-flying military aircraft would be negligible (less than 5 percent of applicable air quality standards) with respect to National Ambient Air Quality Standards (NAAQS) and Prevention of

Significant Deterioration (PSD) Class II air quality increments, which are applicable over most areas of the United States. The air quality impacts of low-flying aircraft were determined to be potentially significant (possibly over 5 percent of applicable standards) only with respect to the more stringent limitations applicable in PSD Class I areas (primarily national parks and wilderness areas above certain sizes). The increments of pollutant concentrations allowed in PSD Class I areas are generally an order of magnitude or more lower than allowed in other areas.

The current NAAQS and PSD Class II and Class I increments are shown in Appendix A. A listing and a map of current PSD Class I areas are shown in Appendix B. Standards occasionally change or are added, and new areas can be redesignated as PSD Class I. Therefore, the air quality analyst is cautioned that appropriate state air pollution control agencies or U.S. Environmental Protection Agency (EPA) regional offices should be consulted periodically to obtain any information about new PSD Class I areas or increments.

An important aspect of the PSD program is that the allowable concentration increments apply only to major stationary pollutant sources. Low-flying aircraft, the emissions sources intended for analysis with the MAILS model, are not subject to any of the regulatory permitting and air quality analysis requirements (including PSD regulations) established pursuant to the Clean Air Act (CAA) and its amendments. The PSD Class I increments were established by the CAA Amendments of 1977 (Pub. L. 95-95) and apply only to major stationary sources of pollutant emissions. However, to satisfy the air quality impact analysis requirements of NEPA, measures established under the CAA (PSD increments and NAAQS) were applied to low-flying aircraft emissions to provide a "yardstick" for evaluating the significance of air quality impacts (Reference 1).

C. SCOPE

The types of airspaces considered in the preliminary draft GEIS for low-altitude flying operations included MTRs, military operations areas (MOAs), and restricted areas (RAs), among others. Existing atmospheric dispersion models were judged appropriate for predicting ground-level pollutant concentrations caused by low-altitude flying operations within MOAs and RAs.

Emissions from MOA and RA flying maneuvers were modeled as continuous area sources using the EPA Industrial Source Complex, Short-Term (ISCST) dispersion model (Reference 2). However, for analysis of MTR pollutant impacts, the development of a new or modified model was deemed necessary. This decision was based on the characteristics of MTR emissions, which consist of intermittent, essentially instantaneous line sources. Therefore, the MAILS model was developed for application to MTRs or other airspaces or airspace segments with consistent flight path orientation similar to MTRs.

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SECTION II

MODEL OVERVIEW

A. DISPERSION MODEL

MAILS is an interactive air quality model that can be used for planning or environmental assessments of MTRs or similar low-altitude airspaces. Low-altitude is defined here as less than 3000 feet above ground-level. This altitude is consistent with the maximum altitude of operations addressed within the context of the GEIS and is also roughly the upper limit of the typical planetary boundary layer, within which atmospheric turbulence and diffusion are largely dependent on the action of wind and solar insolation at the earth's surface. Most atmospheric dispersion models are intended for application within this layer.

The dispersion algorithms used in MAILS are based on the commonly used Gaussian concentration distribution (Reference 3). The line source emissions are assumed to disperse and maintain Gaussian distributions in the horizontal (Y axis, perpendicular to line of release) and vertical directions. To obtain conservative concentration predictions, the wind direction is assumed to be parallel to the line of emissions release for a period of 1 hour. Concentration predictions for averaging periods longer than 1 hour are based on the frequency of expected flights as input by the model user and on empirical averaging time adjustment factors to account for meteorological and flight path variations over these longer periods.

B. AIRCRAFT EMISSIONS DATABASE

The aircraft emissions database contains data for roughly 50 military aircraft, including some non-USAF aircraft. The inclusion of non-USAF aircraft in the database is necessary for assessment purposes because many low-altitude training routes are used by aircraft from more than one branch of the military. The emissions database can be easily updated through the menu-

driven MAILS modeling system as emissions data for new aircraft, fuels, or engines become available.

The database contains a single record for each aircraft and pollutant combination. Since five pollutants are included in the current database, there are approximately 250 total database records. The pollutants represented in the database are sulfur dioxide (SO_2), nitrogen dioxide (NO_2), particulate matter (PART), carbon monoxide (CO), and hydrocarbons (HC). Only the first four pollutants are currently regulated by NAAQS, although HCs contribute to photochemical formation of ozone, for which an NAAQS has been set. Only SO_2, NO_2, and PART are regulated for PSD Class I areas. The NAAQS for PART are now set for particles under ten microns in diameter (PM-10). The PSD increments for PART are still applicable to total particulate matter, although EPA has recently issued a notice of proposed rulemaking to replace them with increments for PM-10 (see Appendix A).

C. MODEL/DATABASE INTEGRATION

A schematic of the MAILS model and database system is shown in Figure 1. Several independent functions can be accomplished with this system: adding or editing database records; printing summary reports from the database; and executing the dispersion model, with results sent either to a disk file or a printer. The FoxBASE® Plus (Revision 2.0) database management system was used to program the database maintenance features and the model input prompts. The executable (compiled with Microsoft® FORTRAN, Version 4.1) MAILS dispersion model was incorporated into this structure.

The integrated system allows the user to model the air quality impact of a single pollutant for several aircraft types in a single model run. The user simply chooses the pollutant to be modeled and the number of aircraft types for a given route segment. The system then displays a menu of aircraft emissions data for selection and prompts for other necessary input, such as the frequency of flights, for the applicable averaging times.

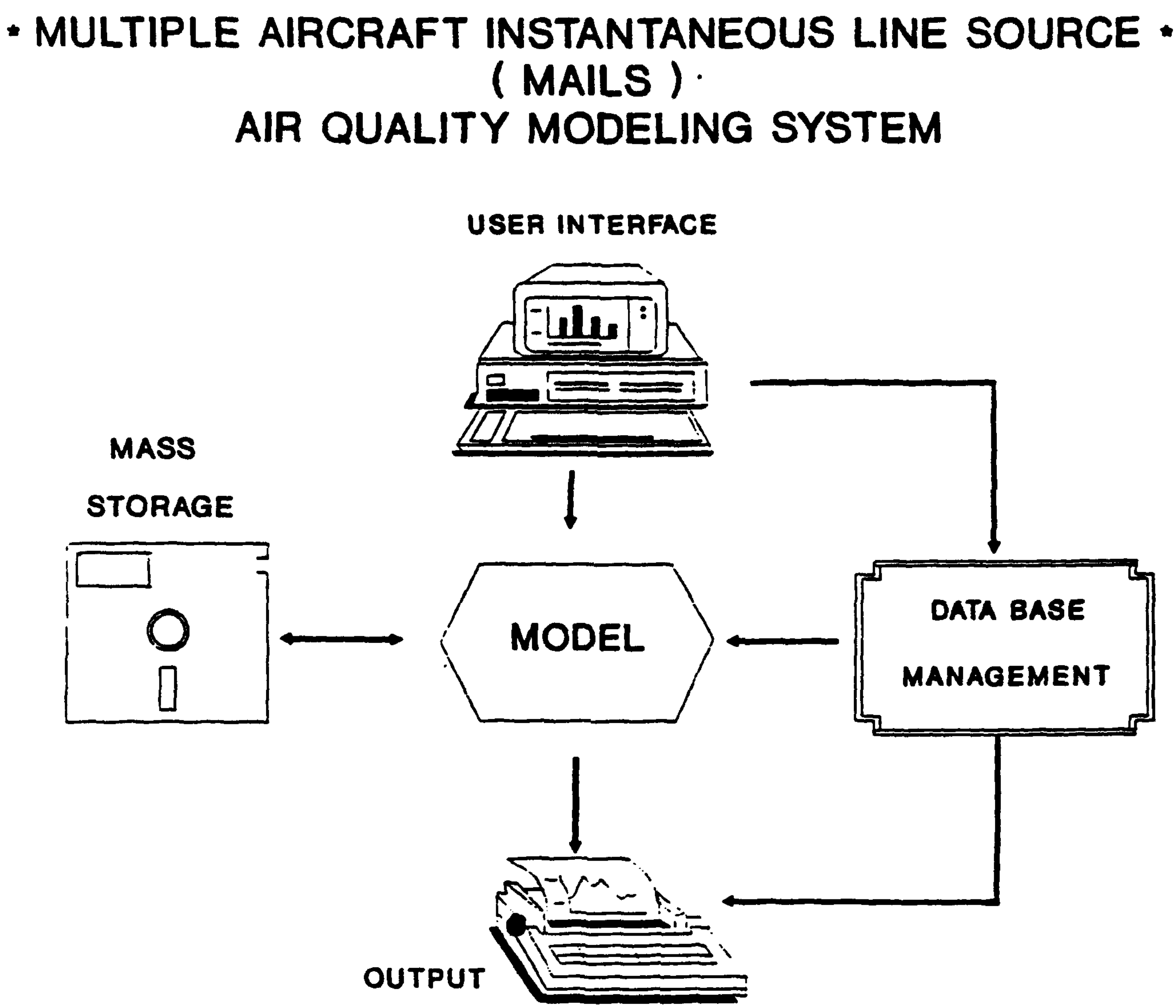


Figure 1. A Schematic of the MAILS Model and Database System.

D. COMPUTER SYSTEM REQUIREMENTS

The MAILS modeling software can be run on systems meeting the following requirements:

1. an IBM®-compatible PC-AT (or an upwardly compatible personal computer (PC) such as 80386-based machines) with PC-DOS® or MS-DOS® (Version 3.0 or later) operating system,

2. a minimum of 360 kB of free memory, and

3. an Epson®-compatible dot matrix printer (80-column) or a printer that can emulate the Epson® character set. Printer port designation of LPT1.

NOTE: Although a math coprocessor (e.g., 80287, 80387) is not required, it is highly recommended since it may reduce execution time by a factor of 5 or 6. If it is known that a math coprocessor is present, then, before executing MAILS, at the DOS prompt, the user should type COPY SAILW.EXE SAILS.EXE. If the math coprocessor is not present, the user should, instead, type COPY SAILWO.EXE SAILS.EXE. If it is not known whether the coprocessor is present, assume it is not.

The MAILS software should be copied to and run from a hard disk. It is advisable to create a separate subdirectory and copy all files on the MAILS diskettes to this subdirectory (see your operating system user's documentation or print the README.DOC file from the MAILS diskettes for instructions).

SECTION III

TECHNICAL DESCRIPTION

A. DISPERSION MODEL

This section describes the design of the MAILS atmospheric dispersion model, the formats of model input and output, and a model performance evaluation. A listing of the MAILS dispersion model FORTRAN computer code is provided in Appendix C.

1. Line Source Simulation

The MAILS dispersion model calculates worst-case (maximum potential) 1-hour concentrations for linear flight paths assumed to be parallel to the wind direction. For a crosswind situation, a ground-level receptor would be impacted for only a brief time after each aircraft pass, resulting in much lower 1-hour concentrations than for the parallel wind case. Concentrations for averaging periods longer than 1 hour are obtained by accounting for (1) the numbers of flights over these longer periods and (2) variations in meteorology and flight paths.

Emissions from a single flight path can be characterized as an essentially instantaneous, infinite line source. The MAILS model divides the instantaneous line source into puffs, each having a pollutant mass equal to the emissions contained in a 100-meter-long segment of flight path. This dispersion modeling concept is illustrated in Figure 2. For calculating the impacts of multiple flights along the same route path over periods of 1 hour or longer, the model simply sums the calculated 1-hour contributions from individual flights and applies averaging period adjustment factors as described later in this section.

For a single aircraft pass, the MAILS model calculates the concentrations for an array of wind speed/atmospheric stability conditions and then selects the maximum concentration for any of these meteorological conditions. These 49 conditions are identical to those used in the PTPLU

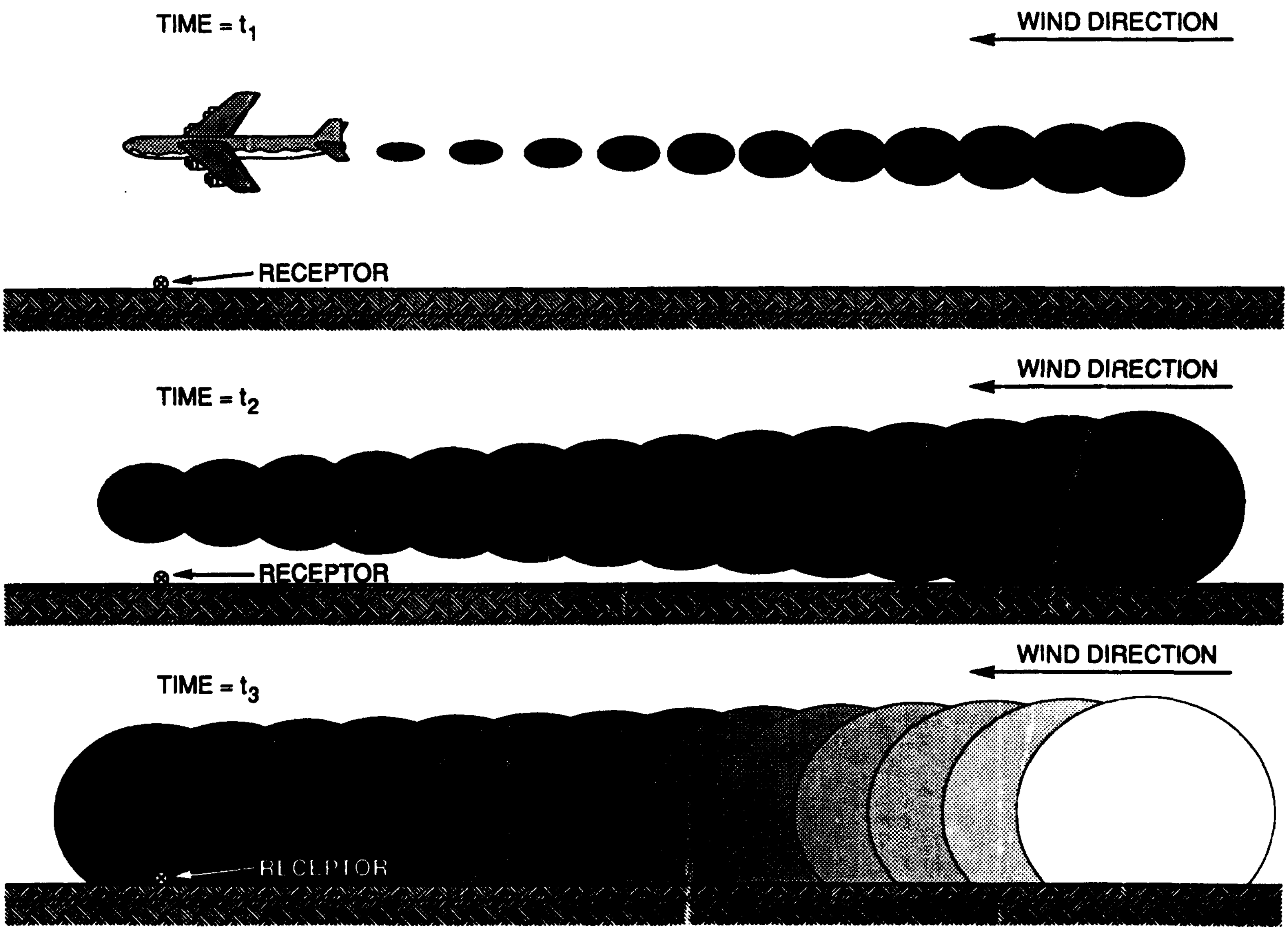


Figure 2. Dispersion Modeling Concept.

model (Reference 4), which is an EPA-approved screening model for single continuous point sources. The MAILS dispersion model assumes wind speed and direction to be constant in space and time.

Concentrations are computed for each wind speed/stability condition at a ground-level, plume centerline location (receptor) by summing the contributions of all the puffs that pass the location in a 1-hour period. The contributions to total exposure from puffs more than 1 hour of travel time away are expected to be small for most meteorological conditions and were not considered in obtaining maximum concentration estimates for periods longer than 1 hour. Furthermore, because low-altitude wind directions are unlikely to remain constant for an hour or more, the same receptor would probably not be exposed to impacts from the centerline of the puffs/plume for longer periods. Thus, the concentrations calculated by the model for a single linear flight path are considered to be conservative (upper-bound) 1-hour estimates.

2. Concentration Calculations

The MAILS model calculates concentrations by summing the exposures (product of concentration and time) from individual puffs that pass the receptor in a 1-hour period and by converting the total exposure to a 1-hour concentration. The mass of each puff is assumed to be distributed according to a Gaussian shape in the vertical (z) and horizontal (x and y) directions. The exposure ψ (g m^{-3} sec) from an individual puff is given by the following equation taken from Slade (Reference 5, p. 115):

$$\psi = \frac{Q}{\pi \sigma_y \sigma_z \bar{u}} \exp \left[- \left[\frac{y^2}{2\sigma_y^2} + \frac{h^2}{2\sigma_z^2} \right] \right] , \qquad (1)$$

where Q is the puff mass (grams), σ_y is the standard deviation (m) of the horizontal puff concentration distribution, σ_z is the standard deviation (m) of the vertical puff concentration distribution, $\bar{u}$ is the average wind speed (m/s), h is the emissions release height (m) above ground-level, and y is the perpendicular distance (m) from the receptor to the plume centerline. Because only the concentration on the plume centerline (at ground level) is calculated by the MAILS model, y is zero and the first term in the exponent drops out.

The preceding equation is appropriate for a situation with essentially unlimited vertical atmospheric mixing. Where limited mixing is important, an expansion of the exponential term is necessary to account for multiple reflections of the Gaussian vertical puff profile off the mixing height inversion and ground surfaces. In such cases the exponential term is expanded in the same manner as done by the ISCST model (Reference 2). The ground-level plume-centerline exposure is then given by

$$\psi = \frac{Q}{\pi \sigma_y \sigma_z \bar{u}} \left\{ \exp\left[-\left[\frac{h}{2\sigma_z} \right]^2 \right] + \left\{ \sum_{n=1}^{\infty} \exp\left[-\left[\frac{2nH-h}{2\sigma_z} \right]^2 \right] + \exp\left[-\left[\frac{2nH-h}{2\sigma_z} \right]^2 \right] \right\} \right\} , \qquad (2)$$

where H is the surface mixing or inversion height.

At downwind distances where the ratio of σ_z/H is greater than 1.6, the puff is essentially uniformly mixed in the vertical direction. The plume centerline exposure from a single puff is then given by the equation

$$\psi = \frac{Q}{\pi \sigma_y \bar{u} H} \quad . \qquad (3)$$

The dispersion coefficients (σ_y and σ_z) used in the MAILS model are identical to those used by the EPA ISCST dispersion model (Reference 2) when the ISCST model is applied to point source plumes without downwash-induced dispersion enhancement, in the "rural" mode. The use of the rural dispersion coefficients is considered appropriate for this application because the MTRs to which the MAILS model is applied would not cross over urban areas. It might be argued that dispersion coefficients for puffs, which are somewhat smaller than for continuous plumes, should be used in the MAILS model. However, it is appropriate to use dispersion coefficients for plumes rather

than for puffs because the puffs are used by the model to simulate a continuous plume produced by the essentially instantaneous line source emissions.

3. Averaging Period Adjustments

Air quality standards are typically established for averaging periods ranging from 1 hour to 1 year (see Appendix A). The MAILS model estimates maximum concentrations for various averaging periods by summing the contributions of individual flights that would occur over the period of interest and by applying empirically derived averaging period adjustment factors. The maximum concentration for a particular averaging period is given by

$$\chi = A \sum_{i=1}^{n} C_i F_i P \quad , \qquad (4)$$

where χ is the maximum concentration (micrograms/m^3), n is the number of different aircraft/altitude combinations being modeled, C_i is the maximum 1-hour concentration contribution (micrograms/m^3) from a single overflight for one aircraft/altitude combination, F_i is the frequency of overflights for one aircraft/altitude combination during the period of interest, P is the period of interest (hours), and A is the averaging period adjustment factor for the period P. The averaging period adjustment factors account for the variations in meteorological conditions and in the horizontal and vertical position of subsequent flights with respect to the route centerline. These factors are subjective estimates based on dispersion modeling experience and based on EPA recommendations (Reference 6) for other types of pollutant sources. The averaging period adjustment factors used for various periods are shown in Table 1.

The 3-hour, 8-hour and 24-hour factors are somewhat lower than similar factors recommended by EPA for relating maximum 1-hour concentrations to longer period maximum concentrations associated with longer periods for continuous elevated point sources (Reference 6). The EPA factors are intended to account for variations in meteorological conditions that cause longer-term

TABLE 1. AVERAGING PERIOD ADJUSTMENT FACTORS

Averaging period	Factor (A)
1 hour	1.00
3 hour	0.50
8 hour	0.33
24 hour	0.25
Annual	0.10

concentrations to be lower than 1-hour concentrations. However, the EPA factors were developed for continuous **stationary** sources, while the factors in Table 1 were developed for an intermittent source, for which each successive emission varies in both horizontal and vertical position relative to a fixed ground-level receptor. The variation in horizontal and vertical position of the successive line sources creates greater effective dispersion of the emissions as averaging time increases, thereby lowering further the appropriate averaging period adjustment factors.

The Table 1 averaging period adjustment factors are not appropriate in situations involving extremely low flight frequencies. For example, if a maximum of one flight is expected in a 3-hour period, flight path variation does not apply, and variations in meteorological conditions over periods greater than 1 hour are not relevant. In such a case it would be appropriate to set A equal to 1.0. However, because routes with very low flight frequencies would generate negligible impacts with respect to PSD Class I increments, this model limitation is not a problem for NEPA analyses or other applications where PSD Class I increments are used as the measure of impact intensity.

4. Model Input

This section describes the input parameters required by the MAILS dispersion model. Some of these parameters can be selected from the emissions

database or, at the user's option, edited upon selection of an aircraft emissions record for a problem run without actual modification of the database file. Other parameters must be input by the user, based on the characteristics of the route segment to be modeled.

Table 2 lists the model input parameters in the sequence in which the user is prompted by the model. Where the parameter type is shown as "D," a default parameter is retrieved from the database upon user selection of an aircraft-pollutant record from a menu and can be modified before input to the model at the option of the user. Where the parameter type is "U," the value for the parameter is a user input.

5. Output Description

The MAILS model output is sent either to a file named by the user during model input, or directly to the printer. If the printer option is chosen, the default output device designation is LPT1. As a backup, in case the printer cannot be accessed, the output is also sent to a file named MODEL.PRT when the printer option is chosen. Some examples of MAILS model output are shown later in Figures 12, 14, and 15. The model output consists of summary tables for each of the applicable averaging periods. Each table shows all model input; the calculated concentration contributions by aircraft type/altitude combination; total concentration for the MTR segment or set of concurrent segments; and, if the standard run mode was selected, the calculated percentage of NAAQS and PSD Class I increment consumed by the modeled MTR segment(s). If the calculated percentage of Class I increment consumption is less than 5 percent for a given pollutant, the MTR segment(s) is considered to have a negligible impact with respect to that pollutant in the Class I area. A more detailed discussion of the application of model output is contained in Sect. IV (B).

6. Model Performance Evaluation

For many types of dispersion models, at least some field measurements are available for an objective assessment of model performance. However, for some types of models the necessary field data do not exist and would be

TABLE 2. DESCRIPTION OF MAILS MODEL INPUT PARAMETERS

Parameter	Type	Description
Title	U	User's description of the model run (e.g., airspace description, date of run).
Run mode	U	User can select standard (S) or nonstandard (N) mode. Choice of the standard mode results in prompts for flight frequency (see "Frequency" parameter below) only for the averaging periods and pollutants with applicable air quality standards (see Appendix A). Choice of the nonstandard mode will result in prompts for frequency for 1-hour, 3-hour, 8-hour, 24-hour, and annual periods and allows modeling of other pollutants.
Pollutant	U	The database contains emissions data for six pollutants. A single pollutant (CO, HC, NO_2, PART, or SO_2) is selected for a model run. Only three pollutants (SO_2, NO_2, and PART) must be considered for a PSD Class I analysis. The user is allowed to choose "OTHER" only if "N" was selected for Run mode (above).
Output option	U	The user enters P to send output directly to the printer (a backup file named MODEL.PRT is also written in this case) or F to send output to a file. If F is selected, the user is prompted for the file name and that file name is then suffixed with .DAT.
Number of aircraft	U	This value is actually the number of aircraft/altitude combinations for the military training route (MTR) segment to be modeled. In nearly all situations, a given aircraft type is assigned only one minimum altitude for a given route or set of concurrent route segments.
Aircraft	D	The aircraft designation, for example, "B-52G," in database is selected by user.

TABLE 2. DESCRIPTION OF MAILS MODEL INPUT PARAMETERS (CONTINUED)

Parameter	Type	Description
Airspeed	D	Average airspeed (miles/hour) of the particular aircraft on MTR operations.
Altitude	U	The minimum altitude (feet) allowed for the particular aircraft on the MTR segment. If the minimum altitude is less than 200 feet, a value of 200 feet is recommended for input unless the aircraft consistently flies below this altitude.
Mixing height	U	The height (in feet) of the surface-based temperature inversion. Use of the default value of 5000 feet (essentially unlimited vertical mixing) is recommended for most applications.
Emission rate	D	Total emission rate (lb/hour) of a single aircraft (all engines) for the selected pollutant.
Frequency	U	Number of passes by the designated aircraft type on the route segment for each applicable averaging period, as determined by run mode and pollutant selection. For example, if the user selects "standard" for run mode and "NO_2" for pollutant, the user will be prompted only for an annual frequency, since only annual standards exist for NO_2. The user is cautioned that this is not always the same as the number of sorties (flights or missions). For example, some MTRs have "racetrack" portions where one aircraft may make several passes during a given sortie.

prohibitively expensive, if not impossible, to gather. This is the case with the MAILS dispersion model.

Some limited field experiments have been conducted to measure ground-level concentrations produced by elevated instantaneous line sources. Such sources were simulated by tracers released from low-flying aircraft (Reference 5, pp. 170–173). However, these experiments were configured so that the line of tracer release was perpendicular to the wind direction. Vertically spaced samplers mounted on a tower and a line of ground-based samplers downwind of the tracer releases recorded the concentrations produced by the tracer as it dispersed. The MAILS model dispersion algorithm simulates worst-case, short-term concentrations produced by an essentially instantaneous elevated release that is parallel to the wind direction. Thus, as shown in Figure 2, a fixed ground-level receptor under the plume centerline would be exposed to emissions for a much longer period, as "puffs" originating from successively farther upwind locations continue to pass over the receptor. The difficulty in conducting a field experiment to measure such impacts would be in creating a tracer release so that the centerline of the emissions would be exactly parallel to the wind direction for several miles upwind of, and in line with, a ground-based monitor (receptor).

Because of the lack of appropriate field data for model comparison, an alternative model evaluation approach was utilized. This approach, in accord with the general guidance provided by EPA (Reference 7), consisted of comparing the results of the MAILS model with the results of the ISCST model (Reference 2), which has already been the subject of a performance evaluation and which can be configured to simulate the type of source to which the MAILS model will be applied.

The following inputs and procedures were used to obtain ISCST results that could be compared to those produced by the MAILS model.

a. Both models were run for a single source.
b. ISCST comparison results were obtained using the "rural" dispersion mode and a wind speed of 10 m/s, under two atmospheric stability categories [Pasquill C and D (see Reference 3)], under both limited and unlimited mixing

situations. Thus, four meteorological cases were generated for comparison.

c. An ISCST emission rate was calculated, based on the 10 m/s wind speed, to provide the same linear emissions density produced by MAILS input for the comparison run.

d. The ISCST structural downwash options were not used, so that the Gaussian plume dispersion parameters would be the same as used by the MAILS model.

e. A 300-foot (91.5-m) stack source, with no plume rise (near-zero exit velocity and stack diameter) was simulated with ISCST to produce a plume of constant height.

f. Receptors were placed every 500 meters in the downwind direction for the ISCST run, out to a distance of 36 km, which would be the distance of puff transport in 1 hour with the 10 m/s wind speed.

g. The 72 concentration results produced by ISCST at the receptors described in Item f were added and divided by 72 to yield values for comparison with the MAILS output.

Use of the ISCST results in the preceding manner produces an average concentration at a receptor that is moving along the centerline of a dispersing plume of constant linear density for a period of 1 hour. The MAILS model, on the other hand, simulates the concentration at a fixed receptor under the centerline of a dispersing plume of constant linear density, which is assumed to move over the receptor for 1 hour. Thus, these converse simulations should produce comparable results, and the verification is shown in Table 3. The differences between the two model results are less than 5 percent for all cases, indicating that the MAILS model performs comparably with an existing validated dispersion model. This result is not unexpected, because identical dispersion coefficients are used in the MAILS model and in the ISCST model as executed for this comparison. Use of the ISCST model for routine air quality analyses of MTRs is undesirable for several reasons: the ISCST model is non-interactive, ISCST requires more detailed and complex input than does MAILS, ISCST is a much larger and therefore less portable program code as compared with MAILS, and manual averaging of ISCST concentration

TABLE 3. COMPARISON OF MULTIPLE AIRCRAFT INSTANTANEOUS LINE SOURCE (MAILS) AND INDUSTRIAL SOURCE COMPLEX, SHORT-TERM (ISCST) MODEL RESULTS

Stability	Mixing height (m)	MAILS concentration (micrograms/m^3)	ISCST concentration (micrograms/m^3)
C	122	5.072	5.069
C	5000	1.781	1.851
D	122	5.883	5.899
D	5000	3.493	3.501

TABLE 4. AIRCRAFT EMISSIONS DATABASE PARAMETERS

Parameter	Type	Field width	Decimal places	Units (if applicable)
Aircraft type	Character	8		
Average speed	Number	3	0	mph
Number of engines	Number	1	0	
Fuel rate per engine	Number	8	2	1000 lb fuel/h
Emission factor	Number	8	2	lb/1000 lb fuel
Emiss. factor flag	Character	1		
Pollutant	Character	4		
Emission rate	Number	8	2	lb/h
Emission density	Number	6	4	lb/mile

estimates at many receptors was necessary to produce the values for comparison.

B. AIRCRAFT EMISSIONS DATABASE

1. Parameters and Format

The aircraft emissions database contains one record for each aircraft/pollutant combination. The parameters, with their formats and units, are listed in Table 4. Most of the parameters in Table 4 are self-explanatory. The emission rate is a product of the number of engines, the fuel rate per engine, and the emission factor, which is given in pounds of pollutant per thousand pounds of fuel. The emission factor flag is a single character that is referenced to a separate file containing text to explain the source of each emission factor in the database.

The emissions density is not used by the model directly but was included in the database to allow the user to screen the emissions data visually to determine potential worst-case MTR segments. If the operating altitudes of two different aircraft are equal, the emissions densities for these aircraft will provide a comparison of relative ground-level concentration caused by the aircraft (i.e., if Aircraft A has an emissions density twice that of Aircraft B, the ground-level concentration caused by Aircraft A will be twice that of Aircraft B). When a record is added to the database, the emissions density is calculated automatically by the database software by dividing the emission rate by the average airspeed.

2. Emissions Data Sources

Most of the aircraft emissions data are based on emission factors and fuel rates drawn from Seitchek (Reference 8). These data have been supplemented with data from other sources (References 9-11). The SO_2 emission rates for all aircraft engines were calculated based on a fuel sulfur content of 0.05 percent, which is on the high end of the numerous aviation fuel test results reported by Shelton (Reference 9). A separate emission factor reference file contains a brief description of the data source or the

assumptions used in obtaining or calculating each emission factor. Each entry in the emission factor reference file is identified by a one character "flag" that corresponds with the emission factor flag used in the main database.

Because air pollutant emission rates vary substantially with engine throttle setting, it is important to choose data representative of the throttle settings used for typical low-altitude flight operations. The emission rates in the database are representative of the "intermediate" engine operating mode as used in Reference 8. The intermediate mode was considered to be the most applicable to the type of cruising operations that would occur on most MTRs. However, data from other sources were not generally categorized using the same terminology used in Reference 8. For these other sources, a data point was chosen that most closely corresponded to approximately 75 percent of the maximum throttle or fuel flow rate under "normal" engine operating conditions, apart from afterburner or other special modes not intended for continuous operation.

The emissions data from Seitchek and other sources are used in a conservative manner in the MAILS model. SO_2 emissions are based on complete conversion of the fuel sulfur to SO_2. NO_2 emissions are based on the assumption that all nitrogen oxides (NO and NO_2) are in the form of NO_2. Finally, total particulate matter emissions are used to produce results for comparison against standards for particulate matter under 10 microns in diameter (PM-10). These conservative assumptions would typically result in SO_2 concentrations that are several percent higher than actual concentrations, and NO_2 and PM-10 concentrations up to roughly a factor of two higher than actual concentrations.

SECTION IV

USING THE MODEL AND DATABASE

A. DATABASE MANIPULATIONS

Most of the aspects of database manipulation are easily understood by moving through the menu screens and, if necessary, using the "Help" options along the way. However, explanations of some of the common types of manipulations are given in the following sections.

1. Editing, Adding, or Deleting Records

a. Emissions File

Emissions file records can be easily modified, added, or deleted by selecting the "Database Maintenance" feature from the MAILS master menu and the "Revise Emissions Database" feature from the DATABASE MAINTENANCE menu that follows. These menus are shown in Figure 3. The program then prompts the user with a screen listing the various database parameters for the first record in the database. An example of this screen is shown in Figure 4. The fields on this first screen cannot be modified at this point; they are intended only to give the user an indication of the type of data in the database. The user can use the menu features at the bottom of the screen to scan the existing data or to add, copy, modify, or delete records. For example, selecting the "add" feature clears the aircraft identification field and most of the other data fields, except for some default values. The user can then enter the desired data in the empty fields, concluding with the emission factor flag. The emission rate is not entered by the user when adding a record; the database computes this value automatically by taking the product of the fuel rate per engine (1000 lb/h), the number of engines, and the emission factor (pounds of pollutant/1000 lb fuel).

```
Air Quality Modeling System                              * Master Menu *

            MULTIPLE AIRCRAFT INSTANTANEOUS LINE SOURCE
                              (MAILS)

                        Run MAILS Model
                        DataBase Maintenance
                        Introductory Screen
                        Quit ...
```

```
Air Quality Modeling System                               * Maint Menu *

              -----  DATABASE MAINTENANCE  -----

                  Revise Emissions DataBase
                  Emissions Flag Ref.
                  Manual Reindex Function
                  Print Emissions Database Summary
                  Help Screen Review
                  Quit ...
```

Figure 3. MAILS Master Menu (top) and Database Maintenance Menu (bottom).

```
Air Quality Modeling System                    Aircraft Emissions Data

     AIRCRAFT IDENTIFICATION  -------->  : A10
     AIRSPEED  ----------------------->  : 405  ( MPH )
     FUEL RATE PER ENGINE  ----------->  :     0.92 (1000 Lb/Hr)
     EMISSION FACTOR  ---------------->  :    16.30 (Lb/1000Lb)
     TYPE OF POLLUTANT  -------------->  : CO
     NUMBER OF ENGINES  -------> : 2     EMISSION FLAG ---> : B
     EMISSION RATE  ------------------>  :    29.99 (Lb/Hr)

Ret/Beg/End/Nxt/Prv/Skp/Mod/Add/Cpy/Del/Lst/Filt/Tally/Help/View/Quit
Retrieve a record by its key fields
```

Figure 4. Single Emissions Record and Menu.

Another way to add a record is to use the "copy" feature. This is especially useful when adding a new record to the database that is very similar to an existing record. In this case the user scrolls through the database to pull up the similar record on the screen. Selecting "Copy" will cause these data to be copied to an identical data entry screen and allow the user to make changes in any of the parameters. When the cursor is moved to a point before the first data field or past the last data field, the software asks the user if the record is to be saved; if the user answers "Y," the record is added to the permanent database.

An easy way to scan the database is to select the "Lst" feature and then use the up/down arrow keys or the page up/page down keys to browse the database quickly. Once a record is highlighted with this feature pressing the "Esc" key will cause this record to be retrieved to the single record display screen for possible manipulation.

There are a number of other useful features in the menu at the bottom of the single record display screen (Figure 4). A one-line explanation of each function is given as the function is highlighted by using the arrow keys. Also, if the user wants to select a particular function from this menu, this can be done either by highlighting the function and pressing "Enter" or by simply typing the first letter of the desired function.

The "View" function allows the user to see the reference documentation for the emission factor. Documentation of the source of each emission factor in the database is contained in the emission factor reference file. Editing and printing of the emission factor reference file is described in the following section.

b. Emission Factor Reference File

This file documents the sources of various emission factor data. If the emissions data file is to be revised, the user should first print a summary of the emission factor reference file and determine if one of the existing references in this file is applicable as a source for a new or revised emission file data. If one of the existing references is applicable, the user should enter the corresponding single-character flag when the emissions record is added or revised. If none of the existing emission factor

references are appropriate for the new data, the user should add a new flag and explanation to the *emission factor reference file.* This can be done by selecting the "Emission Flag Ref." feature from the DATABASE MAINTENANCE screen (Figure 3). The user will then be prompted by the Emissions Factor Document Reference menu (Figure 5, top), from which the user can print a summary of the reference file (Summary Report option) or can revise the database (Database Maintenance option). If the latter is chosen, the screen shown at the bottom of Figure 5 is shown.

Adding, modifying, or deleting new flags is done in a similar manner as for the emissions data file (see Sect. IV A.1.a.). Adding or editing the text that accompanies the flag is done differently. For example, to add a flag and accompanying reference text, the user selects the "Add" feature (see bottom of Figure 5) and the software blanks out the Emissions Reference Flag field. After the desired flag is entered, the user is asked if he would like to edit the document area. If the answer is yes, the screen at the top of Figure 6 is shown. The user must then press the "Ctrl" and "Home" keys to display the text entry screen, shown at the bottom of Figure 6. After the desired text is entered, the user must press the "Ctrl" and "W" keys to write the text to the database record associated with the selected flag.

If the "Help" feature is chosen from the menu shown at the bottom of Figure 5, a brief summary of the options and keystrokes needed to edit the Emission Factor Reference Database is provided.

2. Printing Database Summaries

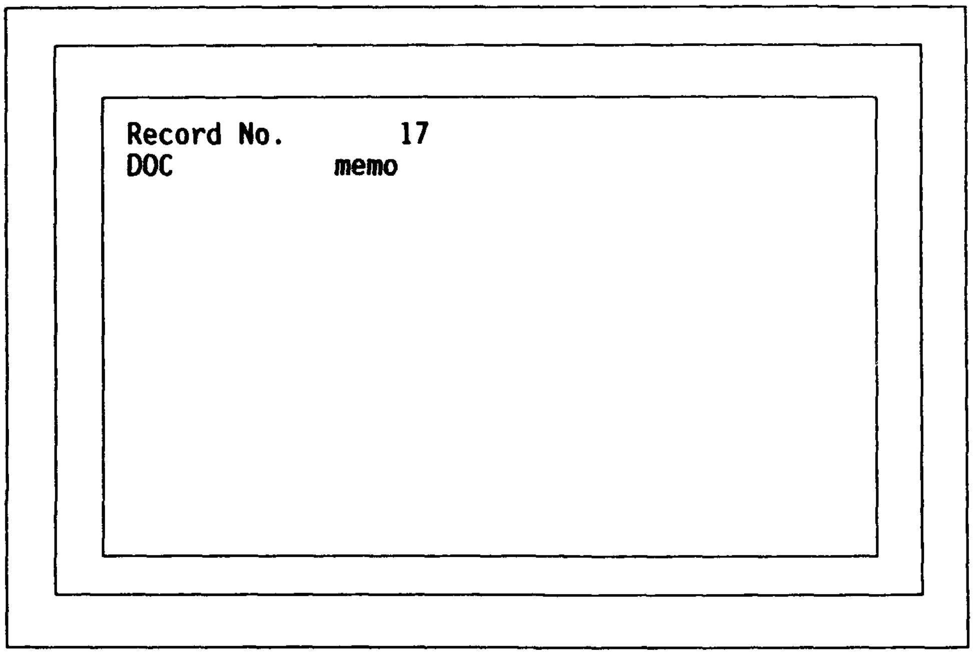
To obtain a hard copy listing of emissions data, the user must select the "Print Emissions Database Summary" option (Figure 3) from the DATABASE MAINTENANCE menu. The user can then browse the data using the "Lst" and other options that will appear as shown at the top screen in Figure 7. If "Go" is selected at this point, a tabular summary will be produced of all records in the emissions database. However, the user can print a summary of a selected set of records by first selecting the "Filt" or filter option. A screen will be displayed with certain database fields empty, but highlighted. The entering of values for any of these fields will then set a filter to select only a portion of the database for the summary report. For example, entering

```
Air Quality Modeling System                          Document Ref. Menu

              * Emissions Factor Document Reference *

                      DataBase Maintenance
                      Summary Report
                      Help Screen Review
                      Quit ...
```

```
Air Quality Modeling System                Emission Factor Ref. DataBase

                Emissions Reference Flag    :  A
```

```
Ret/Beg/End/Nxt/Prv/Skp/Mod/Add/Cpy/Del/Lst/Filt/Tally/+/-/Help/Quit
Retrieve a record by its key fields
```

Figure 5. Emissions Factor Document Reference Menu (top) and Database Maintenance Option Menu (bottom).



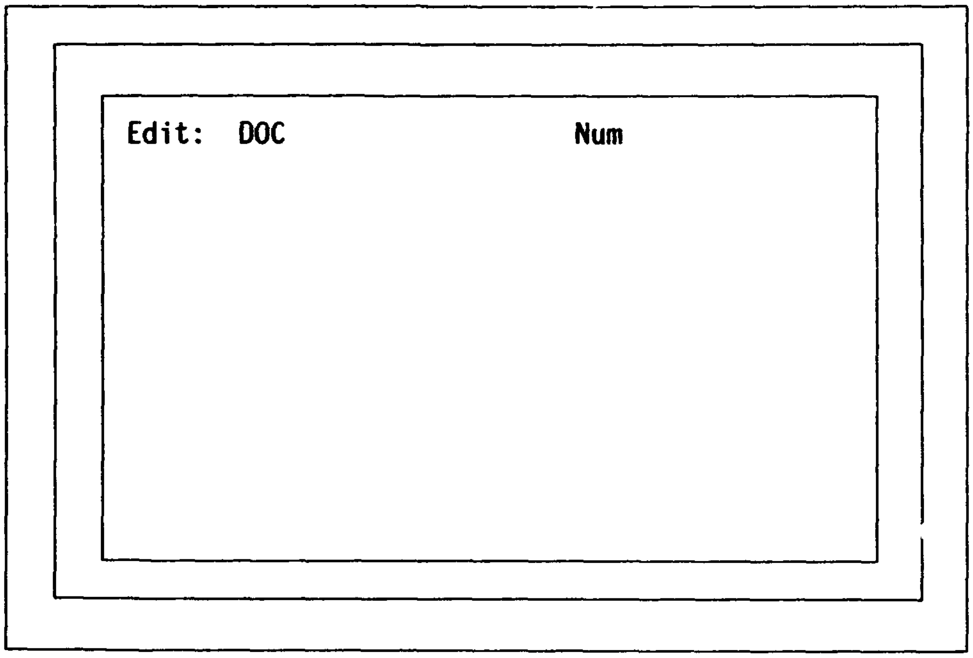


Figure 6. Emission Factor Reference Document Entry Screen (top) and Text Input Screen (bottom).

```
Air Quality Modeling System                           Emissions Data Summary

    AIRCRAFT IDENTIFICATION  -------->  : A10
    AIRSPEED  ----------------------->  : 405  ( MPH )
    FUEL RATE PER ENGINE------------->  :     0.92 (1K Lbs/Hr)
    EMISSION FACTOR  ---------------->  :    16.30 (Lbs/1000Lbs)
    TYPE OF POLLUTANT  -------------->  : CO
    NUMBER OF ENGINES  ------->  : 2     EMISSION FLAG ---> : B
    EMISSION RATE  ------------------>  :           (Lbs/Hr)
Set - Filter : Off
First Record < A10   405
Last  Record > T47   100
```

```
Go/</>/Filt/Beg/End/Nxt/Prv/Skp/Lst/Tally/Help/Quit
Print or display the report
```

```
Air Quality Modeling System                           Emissions Data Summary

    AIRCRAFT IDENTIFICATION  -------->  : F1
    AIRSPEED  ----------------------->  :      ( MPH )
    FUEL RATE PER ENGINE------------->  :     0.00 (1K Lbs/Hr)
    EMISSION FACTOR  ---------------->  :     0.00 (Lbs/1000Lbs)
    TYPE OF POLLUTANT  -------------->  : SO2
    NUMBER OF ENGINES  ------->  :       EMISSION FLAG ---> :
    EMISSION RATE  ------------------>  :     0.00 (Lbs/Hr)
Set - Filter : Off
First Record < A10   405
Last  Record > T47   100
```

```
Filter: Set/Cancel/Quit? S
```

Figure 7. Emissions Data Summary Menu Screen (top) and Filter-Setting Screen (bottom).

Fl in the AIRCRAFT IDENTIFICATION field and SO_2 in the POLLUTANT field (bottom of Figure 7) will cause the filter to be set to select only SO_2 records for aircraft having Fl as the first two characters. After the user spaces past the last open field on this screen, the screen shown at the top of Figure 8 is displayed. If the "Go" option were selected, the report shown at the bottom of Figure 8 would be produced. Before listing the report, the software asks the user if the report is to be sent to either the screen or the printer.

Information from the Emission Factor Reference Database file can also be printed using procedures like those described previously for the Emissions Database. However, for the Emission Factor Reference Database only a single one-character field, the emission factor flag, can be used for selecting or filtering records to print. Therefore, the only possibilities are to print a single record from this file or to print all records. The report selection menu for this file is accessed by selecting "Emissions Flag Ref." from the DATABASE MAINTENANCE menu (Figure 3) and then "Summary Report" from the following menu (Figure 4).

3. Reindexing the Emissions Database

Periodically, after the user has made a number of revisions or additions to the database, it is advisable to reindex the emissions database. Reindexing updates internal database index files, making database manipulations (such as sorting or searching) more efficient. Reindexing is performed by the database management software and takes very little time. All that is required by the user to perform this function is to select the "Manual Reindex Function" item on the DATABASE MAINTENANCE menu. The software does the rest and very shortly returns control of the system to the user.

B. PERFORMING A MODEL RUN

1. Selecting Emissions Data for a Model Run

To initiate the MAILS program, load the program and type "run". Selection of the "Run MAILS Model" from the introductory menu leads to the "Main Menu" from which one chooses a number of options by using the

```
Air Quality Modeling System                        Emissions Data Summary

    AIRCRAFT IDENTIFICATION -------->  : F106
    AIRSPEED ---------------------->  : 520  ( MPH )
    FUEL RATE PER ENGINE------------>  :     8.64 (1K Lbs/Hr)
    EMISSION FACTOR ---------------->  :     1.00 (Lbs/1000Lbs)
    TYPE OF POLLUTANT ------------->  : SO2
    NUMBER OF ENGINES -------> : 1   EMISSION FLAG ---> : D
    EMISSION RATE ----------------->  :     0.00 (Lbs/Hr)
Set - Filter : aircraft='F1' and pollutant='SO2'
First Record < A10   405
Last  Record > T47   100
```

```
Go/</>/Filt/Beg/End/Nxt/Prv/Skp/Lst/Tally/Help/Quit
Print or display the report
```

Page 1

MULTIPLE AIRCRAFT INSTANTANEOUS LINE SOURCE
EMISSIONS DATABASE SUMMARY

Air Craft Type	AVG Speed (MPH)	Fuel Rate 1 Engine (1000 Lb/Hr)	No. of Engines	Pollu Type	Emission Factor (Lb/1000 Lbs)	Emission Rate (Lb/Hr)
F106	520	8.64	1	SO2	1.00	8.64
F111A	550	4.93	2	SO2	1.00	9.86
F111D	550	5.71	2	SO2	1.00	11.42
F111E	550	4.93	2	SO2	1.00	9.86
F111F	550	7.16	2	SO2	1.00	14.32
F14	550	7.40	2	SO2	1.00	14.80
F15	550	5.11	2	SO2	1.00	10.22
F16	550	5.11	1	SO2	1.00	5.11
F18	550	7.50	2	SO2	1.00	15.00

Press any key to continue...

Figure 8. Emissions Data Summary Screen After Filter Has Been Set (top) and Resulting Summary Report (bottom).

up/down arrow keys and the "Enter" key when a choice is made. The 13 items on the main menu are:

- Select Run Title
- Select Standard or Non-standard Aircraft Frequency
- Choose New Pollutant
- Select Output File Name
- Select Mixing Height
- Choose New Aircraft
- Remove Aircraft
- Edit Aircraft Information
- Execute Run
- View Output File
- Retrieve Parameters
- Help Screen
- Quit...

Each relevant menu item is selected by using the arrow and "Enter" keys. The user enters all appropriate information for a particular MAILS run and then chooses the item "Execute Run" to run the dispersion model. After the completion of data entry under any of the menu items from the Main Menu, control is returned to the Main Menu for the next step. Current option settings are displayed below the Main Menu items which the user should monitor. Corrections may be made to any of the entries controlled by the Main Menu by simply choosing the appropriate menu item and then editing the relevant input screen. The following comments relate to the sequential selection of the main menu items:

1. <u>Run Title</u> - Space is allowed for a maximum of 70 characters. Press "Enter" after selection to return to main menu.

2. <u>Select Standard or Non-standard A/C Frequency</u> - The default selection is "Standard(s)" which is displayed at the bottom of the screen. To change, simply type "N"; user is returned to main menu.

3. <u>Choose New Pollutant</u> - Default selection is "CO". Possible other choices are NO2, PART, SO2, ALL (plus HC and OTHER in nonstandard mode). Model is run automatically for <u>all</u> 4 (or 5) pollutants if "ALL" is selected. If entry is mistyped, user is prompted for correction. Press "Enter" to return to main menu.

4. <u>Select Output File Name</u> - Default selection is "P" (Printer). Printer must be ready. If "F" (File) is chosen, output is written to user selected (name).dat. (Data to be printed is also stored in the generic, <u>temporary</u> file "model.dat". Press "Enter" to return to main menu.

5. <u>Select Mixing Height</u> - Default selection is "5000" (ft.). To change value, type in <u>entire</u> new number. (For example, to change from "5000" to "4000", the entire quantity "4000" must be typed; simply editing out the "5" by replacement with "4" will result in a final value of 4 ft.) Press "Enter" to return to main menu.

6. <u>Choose New Aircraft</u> - First screen is for instructions. Type "Esc" to return to main menu or type any other key to view aircraft list. Select one or more aircraft by using arrow keys followed by "Ctrl-End". To exit the aircraft list, type "Esc" which returns to an instruction screen. Type any key to view and edit aircraft selection data. When all Release Altitudes and Flight Frequencies are entered, press "Esc" to return to main menu.

7. <u>Execute Run</u> - This choice results in a calculation using the parameters supplied by the previous options. Results are output either to the printer or the output file named in 4.

8. <u>View Output File</u> - This choice provides for a view of the results of an execution. Use either the arrow or Page Up, Page

Down keys to peruse the file. Press "Esc" to return to the main menu.

9. Retrieve Parameters - This choice results in the current parameters being set to values recorded previously in a file (name).txt. If used, the parameters in (name.txt) will OVERWRITE current settings.

After the completion of a dispersion model run, control is again returned to the Main Menu where some or all of the input data may be changed by again choosing the relevant menu items.

Dispersion model run time depends on the type of computer and on the number of aircraft types selected, but it is relatively short. For example, on a 12-MHz, IBM®-compatible PC-AT, a run for three aircraft types would take approximately a half minute from the time the user completes the data entry portion of the model run. If the results are to be written to an internal file, that file is named (output file name).dat. If the results are to be written to a printer, they will be printed immediately if the printer is ready. Whether or not the printer is ready, the file to be printed is also stored in *model.dat*. If an output file already exists, the user will be asked whether a new run should append the previous file or overwrite it. The default choice is to append, however the user must be cautious so that previous results are not mistakenly overwritten.

Example model outputs are shown in Figures 12, 14, and 15. Interpretation of the model output is explained in the following section.

2. Applying Results

Analysis of NAAQS and/or PSD Class I increment consumption is the intended application of the MAILS model. Because there are three pollutants for which PSD Class I increments have been established (see Appendix A), a typical analysis for a Class I area would require three model runs (unless the ALL option is selected): one each for SO_2, NO_2, and PART. If the user has selected the "standard" operating mode for the model runs, the application of the model results is very simple. The model computes and outputs the amount

of each PSD Class I increment consumed by the route analyzed and also the percentage of the allowable increment represented by the impact. Based on precedent set by EPA regulations (40 CFR 51.167), impacts less than 5 percent of an allowable increment were considered to be insignificant (Reference 1). No further analysis is required in such cases.

If the predicted incremental impact of any route segment is over 5 percent of an allowable Class I increment, the analyst should first verify that the model input values are not overconservative (flight frequencies too high or altitude too low). If the appropriate model input data have been used, further analysis (a cumulative impact assessment) may be required in order to determine the total amount of Class I increment consumed by the combined impacts of the low-level route and other types of pollutant sources. The user should contact the appropriate local, state, or EPA air pollution control agency for information on existing PSD Class I increment consumption in such cases. If other sources have consumed increment in the PSD Class I area of interest, in most cases the appropriate agency should have some model predictions that estimate the amounts of increment already consumed.

Application of the "nonstandard" model run mode may be necessary if air quality standards change (for example, if a 24-hour PSD Class I increment were developed for NO_2) or if for any reason the analyst wants to evaluate the impact of a pollutant for an averaging period not represented in the "standard" run mode. Also, the MAILS model can be used to evaluate impacts of other pollutants and aircraft types that have not been entered in the permanent database for any of the averaging periods (1-hour, 3-hour, 8-hour, 24-hour, and annual) represented in the "nonstandard" mode. This evaluation can be accomplished by entering OTHER for the pollutant type and by entering the appropriate values on the aircraft data entry screen (Figure 11).

C. EXAMPLE APPLICATIONS

The following examples show the types of data that need to be assembled before a modeling exercise; they illustrate how the model user can focus the air quality impact analysis on the MTR segments of greatest concern.

```
Air Quality Modeling System                                  MAILS Model Main Menu

                      *Air Quality Model Interface: Main Menu*

                             SELECT RUN TITLE
                             SELECT STANDARD/NONSTANDARD FREQUENCY
                             CHOOSE NEW POLLUTANT
                             SELECT OUTPUT FILE NAME
                             SELECT MIXING HEIGHT
                             CHOOSE NEW AIRCRAFT
                             REMOVE AIRCRAFT
                             EDIT AIRCRAFT INFORMATION
                             EXECUTE RUN
                             VIEW OUTPUT FILE
                             RETRIEVE PARAMETERS
                             HELP SCREEN
                             Quit...

                        CURRENT OPTION SETTING:

TITLE: EXAMPLE 1
     FREQUENCY: S                                          POLLUTANT: SO2
 OUTPUT FILE: EXAMP1.DAT      NO. AIRCRAFT: 4                MIX HEIGHT: 5000
```

```
AIRCRAFT
A10
A37
A4
A6
A7
AV8
B1B
B52G
B52H
C130
C141
C5
F106
F111A
F111D
F111E
F111F

BROWSE          ‖<C:>‖MAILS                ‖Rec: 1/225        ‖      ‖
                              View and Edit Fields.
```

Figure 9. MAILS Model Main Menu (top) and Aircraft Selection Screen (bottom).

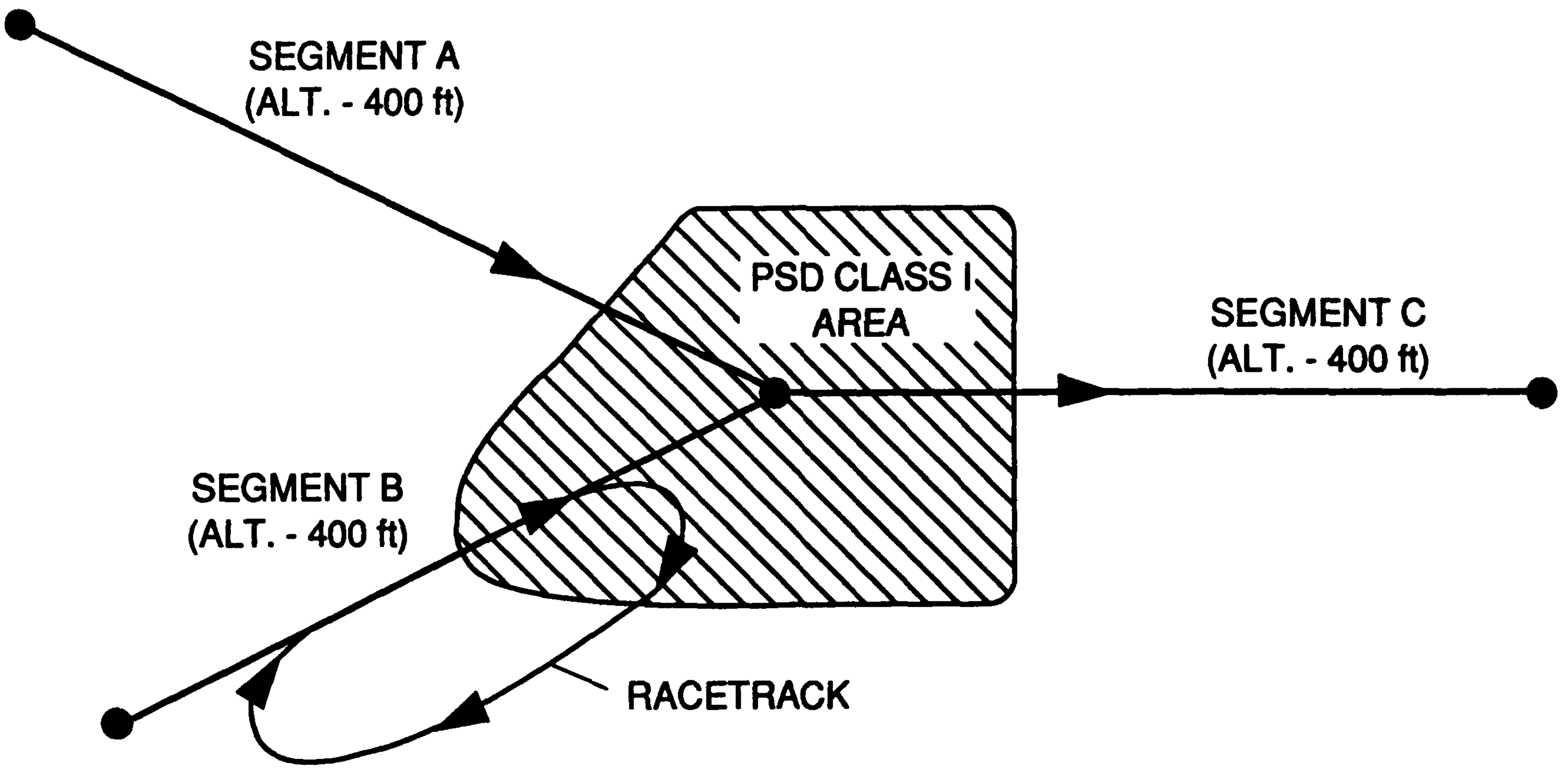


Figure 10. Hypothetical Military Training Route Segments for Example 1.

1. Example 1

Figure 10 shows a hypothetical set of MTR segments that pass over a PSD Class I area. Segments A and B are portions of individual routes that join to form a concurrent route segment (C) over the Class I area. Although three separate line sources exist over different parts of the Class I area, it is obvious that segment C would generate the greatest ground-level impacts because it would have the greatest amount of traffic and because the minimum altitudes of the three route segments are equal. Therefore, only segment C would be modeled to determine the maximum impact with respect to PSD Class I increments.

Table 5 summarizes the aircraft altitude and frequency data that would be used for estimating the air quality impacts of segment C. The other necessary model input data for these aircraft are selected from the emissions database. This hypothetical example assumes that there are no limitations on the mix of the four aircraft types that would be flown over segment C in any given 3-hour or 24-hour period. Therefore, it is important to assess the impacts of the worst-case aircraft type with regard to these short-term periods. The B-52H, the most frequently used aircraft on the route, has emissions densities of SO_2 and PM-10 (for which 24-hour or 3-hour estimates are necessary) that are roughly the same as, or greater than, those of the other aircraft. Therefore, the maximum 24-hour and 3-hour flight frequencies are based on the assumption that all flights during these periods could be made by B-52H aircraft. Because the emissions densities of various aircraft can be compared by browsing through the emissions database (see Figure 9, top), the 3-hour and 24-hour frequencies are input as zero for the other aircraft types when the model runs are made for SO_2. Based on scheduling or other limitations, it is assumed that a B-52H could cross the route segment a maximum of 6 times in 3 hours or 16 times in 24 hours.

The analysis of PSD Class I increment consumption is accomplished with three model runs (one if ALL is selected): one each for NO_2, SO_2, and PM-10. The model input and output for the SO_2 run are discussed for this example.

The MAILS system is started by typing "run" (displays title screen) or "mails" (bypasses title screen) at the DOS prompt and pressing "Enter." After

TABLE 5. AIRCRAFT INPUT DATA FOR EXAMPLE 1

Segment	Aircraft	Minimum Altitude (ft.)	Maximum Flight Frequency 3-h	24-h	Annual
A	B52G	400			200
A	B52H	400			500
A	B1B	400			100
B	FB111	400			300/450[a]
B	B1B	400			100/150[a]
C	B52G	400	6	16	200
C	B52H	400			500
C	B1B	400			200
C	FB111	400			300

[a]The numerator denotes the total annual number of flights (sorties) on this MTR segment, but because half of the flights are expected to make a second pass on segment B via the "racetrack", the total number of aircraft passes for segment B would be as shown in the denominator.

"Run MAILS Model" is selected from the master menu, the system displays the model main menu (Figure 9, top) to allow selection of aircraft, run mode, pollutant (the user selects SO_2), and other data as described in section IV.B.1 above. When all appropriate input data has been entered, the user selects "Execute Run" from the main menu to perform calculations for all selected aircraft. A confirmation screen appears to remind the user that output will be written to either the printer or to the user-specified output file. The user presses "enter", and model execution begins. The MAILS model computes the maximum increases (increments) in 3-hour, 24-hour and annual SO_2 concentrations and also the percentages of the allowable PSD Class I and NAAQS increments represented by these impacts. These values are then output directly to the printer or to a user-named print file, depending on the user's preference as selected during the model input phase. Model output is also sent to a backup print file (filename = MODEL.PRT) when the option is chosen to send output directly to the printer.

The MAILS results shown in Figure 12 indicate that the maximum 3-hour, 24-hour and annual SO_2 concentrations are less than 5 percent of the allowable PSD Class I increments. Therefore, the impacts of the MTR segment on PSD Class I SO_2 increments are considered negligible, and no further analysis is required for SO_2. Additional model runs for NO_2 and PM-10 would complete the analysis of air quality for the PSD Class I area.

2. Example 2

Figure 13 shows a hypothetical set of MTR segments, two of which cross two separate PSD Class I areas. Table 6 shows the aircraft altitude and frequency data used for this example. The other necessary model input data for these aircraft were those contained in the emissions database.

The most efficient analytical approach would be to first attempt to determine by inspection if one of the Class I area segments would clearly cause a greater impact than the other. The worst-case segment could then be modeled, and if the predicted impacts were negligible (<5 percent of any PSD Class I increment) for all pollutants, the other segment would not have to be modeled. In this case, segment C clearly has the greatest cumulative emissions density, while segment A has a lower minimum altitude. Therefore,

AIRCRAFT	SPEED	EMISS_RATE	REL_ALT	FREQ_3HR	FREQ_24HR	FREQ_ANN	POLLUTANT
B52G	400	53.52	400	6	16	200	SO2
B52H	400	49.92	400	0	0	500	SO2
B1B	610	20.44	400	0	0	200	SO2
FB111	550	11.42	400	0	0	300	SO2

BROWSE ‖<C:>‖MODEL ‖Rec: 1/6 ‖ ‖

View and Edit Fields.

Figure 11. Aircraft Data Entry/Edit Screen.

MAILS - VERSION 3.0: MULTIPLE AIRCRAFT INSTANTANEOUS LINE SOURCE MODEL

EXAMPLE 1 *********

Pollutant : SO2
Avg. Period: 3-hour

No. of Aircraft (Types) : 4
Mixing Height : 5000 ft.

Aircraft	Altitude (ft)	Airspeed (mph)	Emiss. Rate (lb/hr)	Flight Freq.	3-hour Conc. (micrograms/m**3)
B52G	400	400	53.52	6	.2269
B52H	400	400	49.92	0	0.00E+00
B1B	400	610	20.44	0	0.00E+00
FB111	400	550	11.42	0	0.00E+00
			Total 3-hour conc. =		.2269

The total 3-hour conc. is .9076 % of the PSD
Class I 3-hour increment for SO2 (25 micrograms/m**3)

EXAMPLE 1 *********

Pollutant : SO2
Avg. Period: 24-hour

No. of Aircraft (Types) : 4
Mixing Height : 5000 ft.

Aircraft	Altitude (ft)	Airspeed (mph)	Emiss. Rate (lb/hr)	Flight Freq.	24-hour Conc. (micrograms/m**3)
B52G	400	400	53.52	16	.0378
B52H	400	400	49.92	0	0.00E+00
B1B	400	610	20.44	0	0.00E+00
FB111	400	550	11.42	0	0.00E+00
			Total 24-hour conc. =		.0378

The total 24-hour conc. is .7563 % of the PSD
Class I 24-hour increment for SO2 (5 micrograms/m**3)

EXAMPLE 1 *********

Pollutant : SO2
Avg. Period: Annual

No. of Aircraft (Types) : 4
Mixing Height : 5000 ft.

Aircraft	Altitude (ft)	Airspeed (mph)	Emiss. Rate (lb/hr)	Flight Freq.	Annual Conc. (micrograms/m**3)
B52G	400	400	53.52	200	.0005
B52H	400	400	49.92	500	.0012
B1B	400	610	20.44	200	.0001
FB111	400	550	11.42	300	.0001
			Total annual conc. =		.0020

The total annual conc. is .0988 % of the PSD
Class I annual increment for SO2 (2 micrograms/m**3)

Figure 12. MAILS SO_2 Results for Example 1.

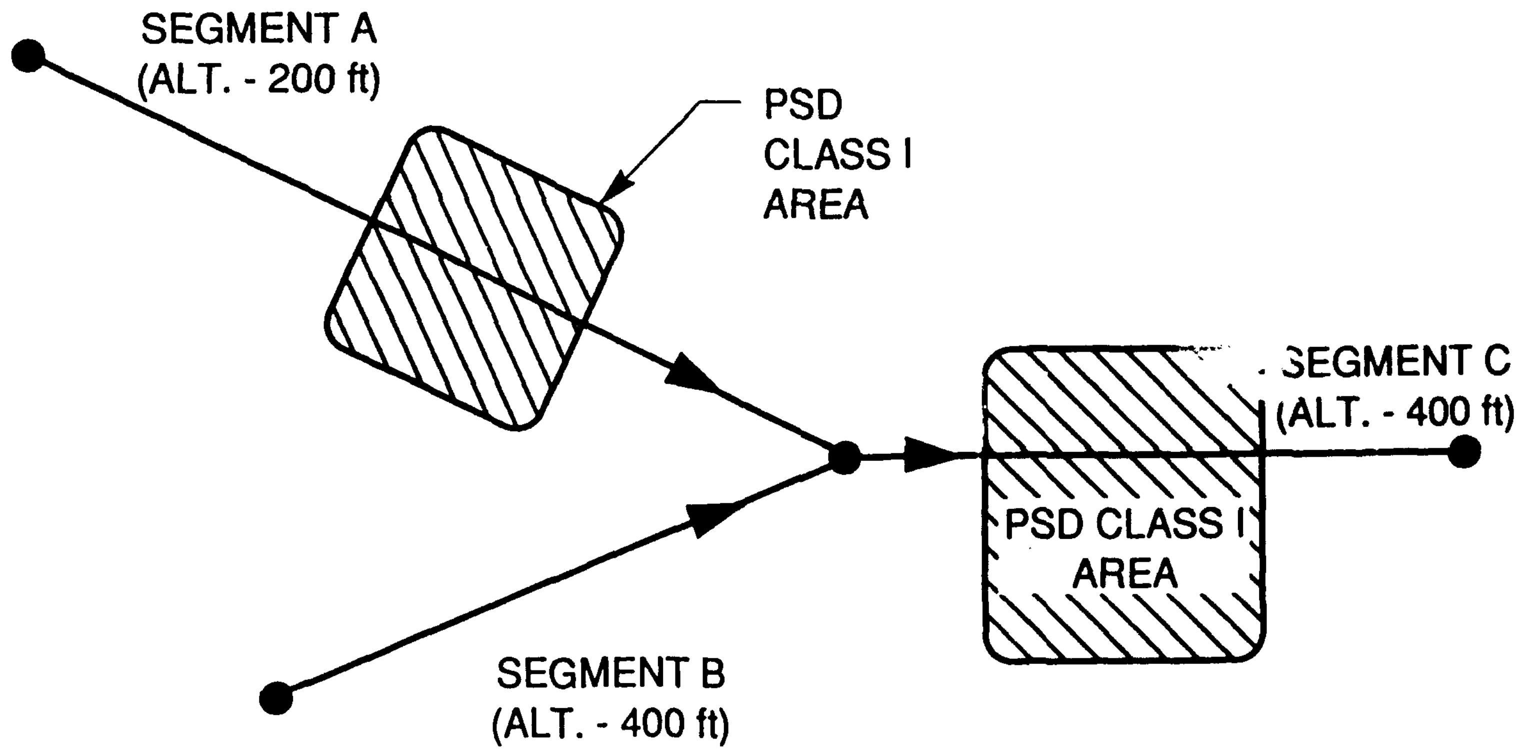


Figure 13. Hypothetical Military Training Route Segments for Example 2.

TABLE 6. AIRCRAFT INPUT DATA FOR EXAMPLE 2

Segment	Aircraft	Minimum Altitude (ft.)	Maximum Flight Frequency 3-h	24-h	Annual
A	A10	200			400
A	F4E	200	8	20	400
A	F16	200			400
B	F4E	400			800
C	A10	400			400
C	F4E	400	12	30	1200
C	F16	400			400

it cannot readily be determined beforehand which segment would cause the greatest ground-level concentrations (i.e., both segments must be modeled).

The input data entry screens are not shown for this example since they will be basically the same as for the preceding Example 1 except for different data values. Only the output results for SO_2, which are shown in Figures 14 and 15, are discussed for this example.

The MAILS results indicate that the incremental 3-hour, 24-hour, and annual SO_2 concentrations will be negligible (<5 percent) with respect to the corresponding PSD Class I increments at both of the hypothetical PSD Class I areas shown in Figure 13. Note that the predicted concentrations were somewhat greater for segment A than for segment C. Thus, the lower minimum altitude on segment A more than outweighed the greater emissions density (more flights) on segment C. Additional model runs for NO_2 and PM-10 for each of the Class I areas would complete the air quality analysis.

MAILS - VERSION 3.0: MULTIPLE AIRCRAFT INSTANTANEOUS LINE SOURCE MODEL

EXAMPLE 2, SEGMENT A *********

Pollutant : SO2
Avg. Period: 3-hour

No. of Aircraft (Types) : 3
Mixing Height : 5000 ft.

Aircraft	Altitude (ft)	Airspeed (mph)	Emiss. Rate (lb/hr)	Flight Freq.	3-hour Conc. (micrograms/m**3)
A10	200	405	1.84	0	0.00E+00
F4E	200	550	14.00	8	.1692
F16	200	550	5.11	0	0.00E+00
			Total 3-hour conc. =		.1692

The total 3-hour conc. is .6767 % of the PSD
Class I 3-hour increment for SO2 (25 micrograms/m**3)

EXAMPLE 2, SEGMENT A *********

Pollutant : SO2
Avg. Period: 24-hour

No. of Aircraft (Types) : 3
Mixing Height : 5000 ft.

Aircraft	Altitude (ft)	Airspeed (mph)	Emiss. Rate (lb/hr)	Flight Freq.	24-hour Conc. (micrograms/m**3)
A10	200	405	1.84	0	0.00E+00
F4E	200	550	14.00	20	.0264
F16	200	550	5.11	0	0.00E+00
			Total 24-hour conc. =		.0264

The total 24-hour conc. is .5286 % of the PSD
Class I 24-hour increment for SO2 (5 micrograms/m**3)

EXAMPLE 2, SEGMENT A *********

Pollutant : SO2
Avg. Period: Annual

No. of Aircraft (Types) : 3
Mixing Height : 5000 ft.

Aircraft	Altitude (ft)	Airspeed (mph)	Emiss. Rate (lb/hr)	Flight Freq.	Annual Conc. (micrograms/m**3)
A10	200	405	1.84	400	.0001
F4E	200	550	14.00	400	.0006
F16	200	550	5.11	400	.0002
			Total annual conc. =		.0009

The total annual conc. is .0447 % of the PSD
Class I annual increment for SO2 (2 micrograms/m**3)

Figure 14. MAILS SO_2 Results for Example 2, Segment A.

MAILS - VERSION 3.0: MULTIPLE AIRCRAFT INSTANTANEOUS LINE SOURCE MODEL

EXAMPLE 2, SEGMENT C *********

Pollutant : SO2 No. of Aircraft (Types) : 3
Avg. Period: 3-hour Mixing Height : 5000 ft.

Aircraft	Altitude (ft)	Airspeed (mph)	Emiss. Rate (lb/hr)	Flight Freq.	3-hour Conc. (micrograms/m**3)
A10	400	405	1.84	0	0.00E+00
F4E	400	550	14.00	12	.0863
F16	400	550	5.11	0	0.00E+00
			Total 3-hour conc. =		.0863

The total 3-hour conc. is .3453 % of the PSD
Class I 3-hour increment for SO2 (25 micrograms/m**3)

EXAMPLE 2, SEGMENT C *********

Pollutant : SO2 No. of Aircraft (Types) : 3
Avg. Period: 24-hour Mixing Height : 5000 ft.

Aircraft	Altitude (ft)	Airspeed (mph)	Emiss. Rate (lb/hr)	Flight Freq.	24-hour Conc. (micrograms/m**3)
A10	400	405	1.84	0	0.00E+00
F4E	400	550	14.00	30	.0135
F16	400	550	5.11	0	0.00E+00
			Total 24-hour conc. =		.0135

The total 24-hour conc. is .2698 % of the PSD
Class I 24-hour increment for SO2 (5 micrograms/m**3)

EXAMPLE 2, SEGMENT C *********

Pollutant : SO2 No. of Aircraft (Types) : 3
Avg. Period: Annual Mixing Height : 5000 ft.

Aircraft	Altitude (ft)	Airspeed (mph)	Emiss. Rate (lb/hr)	Flight Freq.	Annual Conc. (micrograms/m**3)
A10	400	405	1.84	400	3.52E-05
F4E	400	550	14.00	1200	.0006
F16	400	550	5.11	400	7.19E-05
			Total annual conc. =		.0007

The total annual conc. is .0349 % of the PSD
Class I annual increment for SO2 (2 micrograms/m**3)

Figure 15. MAILS SO_2 Results for Example 2, Segment C.

SECTION V

CONCLUSIONS

This user's guide provides a detailed description of the interactive MAILS air quality model and instructions for its use. MAILS is a simple screening model, providing estimates of worst-case concentrations for MTRs. The model incorporates an aircraft pollutant emissions database to allow convenient user input for problem runs.

The intended application of the MAILS model is the prediction of ground-level pollutant concentrations resulting from low-flying (under 3000 feet above ground-level) military aircraft operations along a prescribed route. Previous studies have demonstrated that air quality impacts from low-flying military aircraft are (1) negligible with respect to NAAQS and PSD Class II air quality increments and (2) potentially significant with respect to PSD Class I air quality increments, which apply primarily to certain national parks and wilderness areas. Therefore, the instructions and example applications described in this report focus on the use of the MAILS model for analysis of air quality impacts on PSD Class I areas.

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APPENDIX A

NATIONAL AMBIENT AIR QUALITY STANDARDS (NAAQS)
AND PREVENTION OF SIGNIFICANT DETERIORATION (PSD) INCREMENTS[a]

Pollutant	Averaging time	NAAQS	PSD Increments Class II	PSD Increments Class I
Nitrogen dioxide	Annual	100	25	2.5
Sulfur dioxide	3-hour	1,300[b]	512[b]	25[b]
	24-hour	365[b]	91[b]	5[b]
	Annual	80	20	2
Particulate matter[c]	24-hour	150[b]	30[b,d]	8[b,d]
	Annual	50	17[d]	4[d]
Carbon monoxide	1-hour	40,000[b]		
	8-hour	10,000[b]		
Ozone	1-hour	235[e]		
Lead	Calendar quarter	1.5		

[a]All concentrations are in units of micrograms/m^3.
[b]Not to be exceeded more than once per year.
[c]Particulate matter under 10 microns in diameter (PM-10).
[d]Listed PM-10 Class II and I increments were recently proposed, pending final rule promulgation.
[e]Not to be exceeded on more than one day per year.

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APPENDIX B

PREVENTION OF SIGNIFICANT DETERIORATION CLASS I AIR QUALITY AREAS

Figure B-1 shows the PSD Class I areas that were designated under the Clean Air Act amendments of 1977. A listing of these areas by states is provided in Table B-1. An additional area, the Northern Cheyenne Indian Reservation in Montana, was redesignated later to PSD Class I status. More detailed maps of particular PSD Class I areas can be obtained from the U.S. Department of Interior, Bureau of Land Management. The "state wilderness maps" available from this agency should provide sufficient resolution of parks and wilderness areas for those involved in the analysis of MTR air quality impacts on PSD Class I areas.

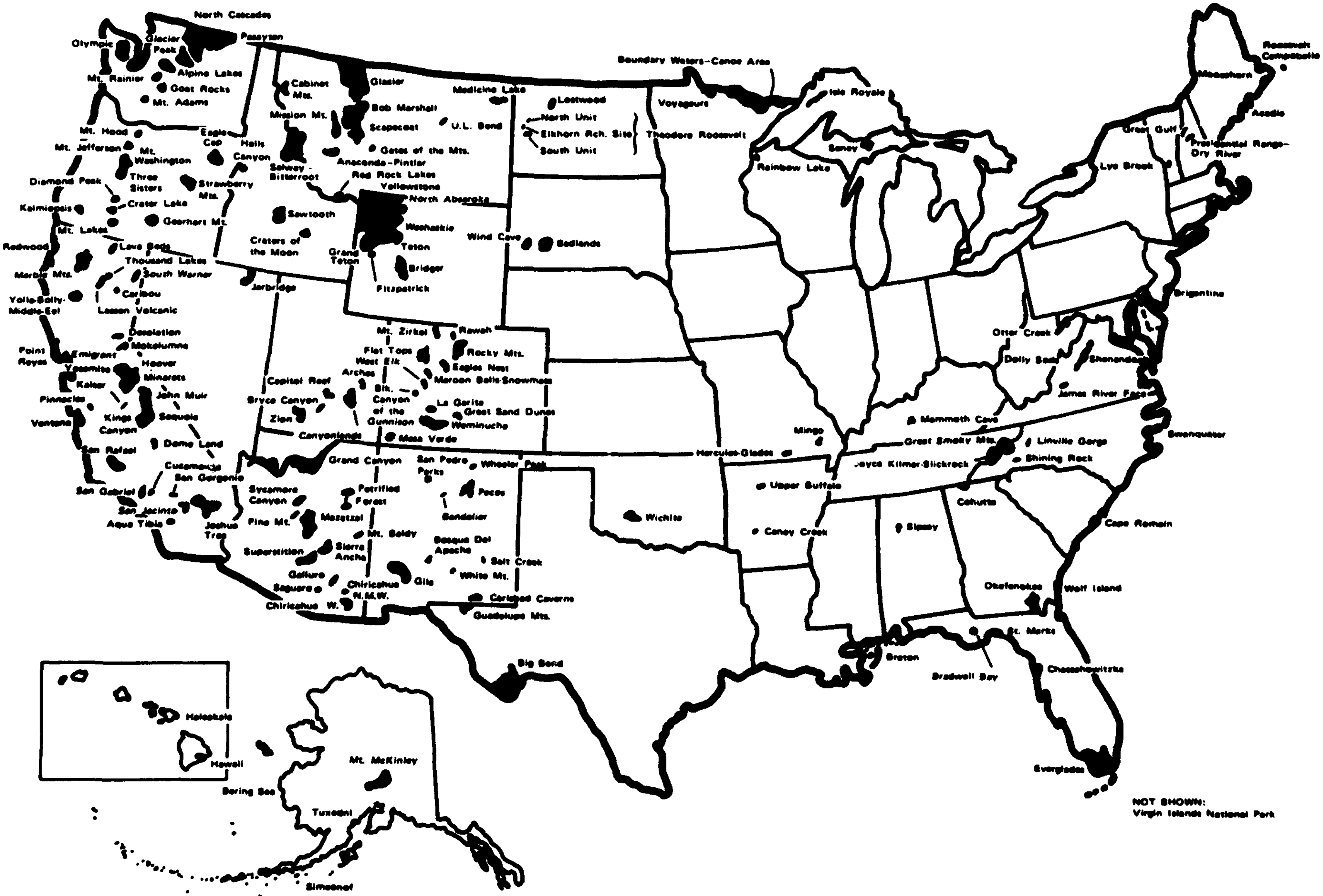

Figure B-1. PSD Class I Areas Designated Under the Clean Air Act Amendments of 1977.

TABLE B-1. PSD CLASS I AREAS DESIGNATED UNDER THE CLEAN AIR ACT AMENDMENTS OF 1977

Area names[1]	State	Acreage	Establishing Public Law	Federal Land Manager
Sipsey Wild.	AL	12,646	93-622	USDA-FS
Bering Sea Wild.	AK	41,113	91-622	USDI-FWS
Mount McKinley NP	AK	1,939,493	64-353	USDI-NPS
Simeonof Wild.	AK	25,141	94-557	USDA-FWS
Tuxedni Wild.	AK	6,402	91-504	USDI-FWS
Chiricahua National Monument Wild.	AZ	9,440	94-567	USDI-NPS
Chiricahua Wild	AZ	18,000	88-577	USDA-FS
Galiuro Wild.	AZ	52,717	88-577	USDA-FS
Grand Canyon NP	AZ	1,176,913	65-277	USDI-NPS
Mazatzal Wild.	AZ	205,137	88-577	USDA-FS
Mount Baldy Wild.	AZ	6,975	91-504	USDA-FS
Petrified Forest NP	AZ	93,493	85-358	USDI-NPS
Pine Mtn. Wild.	AZ	20,061	92-230	USDA-FS
Saguaro Wild.	AZ	71,400	94-567	USDI-NPS
Sierra Ancha Wild.	AZ	20,850	88-577	USDA-FS
Superstition Wild.	AZ	124,117	88-577	USDA-FS
Sycamore Canyon Wild.	AZ	47,757	92-241	USDA-FS
Caney Creek Wild.	AR	14,344	93-622	USDA-FS
Upper Buffalo Wild.	AR	9,912	93-622	USDA-FS
Agua Tibia Wild.	CA	15,934	93-632	USDA-FS
Caribou Wild.	CA	19,080	88-577	USDA-FS
Cucamonga Wild.	CA	9,022	88-577	USDA-FS
Desolation Wild.	CA	63,469	91-82	USDA-FS
Dome Land Wild.	CA	62,206	88-577	USDA-FS
Emigrant Wild.	CA	104,311	93-632	USDA-FS
Hoover Wild.	CA	47,916	88-577	USDA-FS
John Muir Wild.	CA	484,673	88-577	USDA-FS
Joshua Tree Wild.	CA	429,690	94-567	USDI-NPS
Kaiser Wild.	CA	22,500	94-577	USDA-FS
Kings Canyon NP	CA	459,994	76-424	USDI-NPS
Lassen Volcanic NP	CA	105,800	64-184	USDI-NPS
Lava Beds Wild.	CA	28,640	92-493	USDI-NPS
Marble Mtn. Wild.	CA	213,743	88-577	USDA-FS

TABLE B-1. PSD CLASS I AREAS DESIGNATED UNDER THE CLEAN AIR ACT AMENDMENTS OF 1977 (CONTINUED)

Area names[1]	State	Acreage	Establishing Public Law	Federal Land Manager
Minarets Wild.	CA	109,484	88-577	USDA-FS
Mokelumne Wild.	CA	50,400	88-577	USDA-
FSPinnacles Wild.	CA	12,952	94-567	USDI-NPS
Point Reyes Wild.	CA	25,370	94-544, 94-567	USDI-NPS
Redwood NP	CA	27,792	90-545	USDI-NPS
San Gabriel Wild.	CA	36,137	90-318	USDA-FS
San Gorgonio Wild.	CA	34,644	88-577	USDA-FS
San Jacinto Wild.	CA	20,564	88-577	USDA-FS
San Rafael Wild.	CA	142,722	90-271	USDA-FS
Sequoia NP	CA	386,642	26 Stat. 478 (51st Cong.)	USDI-NPS
South Warner Wild.	CA	68,507	88-577	USDA-FS
Thousand Lakes Wild.	CA	15,695	88-577	USDA-FS
Ventana Wild.	CA	95,152	91-58	USDA-FS
Yolla-Bolly-Middle-Eel Wild.	CA	109,091	88-577	USDA-FS
Yosemite NP	CA	759,172	58-49	USDI-NPS
Black Canyon of the Gunnison Wild.	CO	11,180	94-567	USDI-NPS
Eagles Nest Wild.	CO	133,910	94-352	USDA-FS
Flat Tops Wild.	CO	235,230	94-146	USDA-FS
Great Sand Dunes Wild.	CO	33,450	94-567	USDI-NPS
La Garita Wild.	CO	48,486	88-577	USDA-FS
Maroon Bells-Snowmass Wild.	CO	71,060	88-577	USDA-FS
Mesa Verde NP	CO	51,488	59-353	USDI-NPS
Mt. Zirkel Wild.	CO	72,472	88-577	USDA-FS
Rawah Wild.	CO	26,674	88-577	USDA-FS
Rocky Mountain NP	CO	263,138	63-238	USDI-NPS
Weminuche Wild.	CO	400,907	93-632	USDA-FS
West Elk Wild.	CO	61,412	88-577	USDA-FS
Bradwell Bay Wild.	FL	23,432	93-622	USDA-FS
Chassahowitzka Wild.	FL	23,360	94-557	USDI-FWS
Everglades NP	FL	1,397,429	73-267	USDI-NPS
St. Marks Wild.	FL	17,745	93-632	USDI-FWS
Cohotta Wild.	GA	33,776	93-622	USDA-FS

TABLE B-1. PSD CLASS I AREAS DESIGNATED UNDER THE CLEAN AIR ACT AMENDMENTS OF 1977 (CONTINUED)

Area names[1]	State	Acreage	Establishing Public Law	Federal Land Manager
Okefenokee Wild.	GA	343,850	93-429	USDI-FWS
Wolf Island Wild.	GA	5,126	93-632	USDI-FWS
Haleakala NP	HI	27,208	86-744	USDI-NPS
Hawaii Volcanoes	HI	217,029	64-171	USDI-NPS
Craters of the Moon Wild.	ID	43,243	91-504	USDI-NPS
Hells Canyon Wild.[2]	ID	83,800	94-199	USDA-FS
Sawtooth Wild.	ID	216,383	92-400	USDA-FS
Selway-Bitterroot Wild.[3]	ID	988,770	88-577	USDA-FS
Yellowstone NP[4]	ID	31,488	17 Stat. 32 (42nd Cong.)	USDI-NPS
Mammoth Cave NP	KY	51,303	69-283	USDI-NPS
Breton Wild.	LA	5,000+	93-632	USDI-FWS
Acadia NP	ME	37,503	65-278	USDI-NPS
Moosehorn Wild.	ME	7,501		USDI-FWS
(Edmunds Unit)		(2,782)	91-504	
(Baring Unit)		(4,719)	93-632	
Isle Royale NP	MI	542,428	71-835	USDI-NPS
Seney Wild.	MI	25,150	91-504	USDI-FWS
Boundary Waters Canoe Area Wild.	MN	747,840	88-577	USDA-FS
Voyageurs NP	MN	114,964	99-261	USDI-NPS
Hercules-Glades Wild.	MO	12,315	94-557	USDA-FS
Mingo Wild.	MO	8,000	94-557	USDI-FWS
Anaconda-Pintlar Wild.	MT	157,803	88-577	USDA-FS
Bob Marshall Wild.	MT	950,000	88-577	USDA-FS
Cabinet Mtns. Wild.	MT	94,272	88-577	USDA-FS
Gates of the Mtn Wild.	MT	28,562	88-577	USDA-FS
Glacier NP	MT	1,012,599	61-171	USDI-NPS

TABLE B-1. PSD CLASS I AREAS DESIGNATED UNDER THE CLEAN AIR ACT AMENDMENTS OF 1977 (CONTINUED)

Area names[1]	State	Acreage	Establishing Public Law	Federal Land Manager
Medicine Lake Wild.	MT	11,366	94-557	USDI-FWS
Mission Mtn. Wild.	MT	73,877	93-632	USDA-FS
Red Rock Lakes Wild.	MT	32,350	94-557	USDI-FWS
Scapegoat Wild.	MT	239,295	92-395	USDA-FS
Selway-Bitterroot Wild.[3]	MT	251,930	88-577	USDA-FS
U.L. Bend Wild.	MT	20,890	94-557	USDI-FWS
Yellowstone NP[4]	MT	167,624	17 Stat. 32 (42nd Cong.)	USDI-NPS
Jarbridge Wild.	NV	64,667	88-577	USDA-FS
Great Gulf Wild.	NH	5,552	88-577	USDA-FS
Presidential Range-Dry River Wild.	NH	20,000	93-622	USDA-FS
Brigantine Wild.	NJ	6,603	93-632	USDI-FWS
Bandelier Wild.	NM	23,267	94-567	USDI-NPS
Bosque del Apache Wild.	NM	30,850	93-632	USDI-FWS
Carlsbad Caverns NP	NM	46,435	71-216	USDI-NPS
Gila Wild.	NM	433,690	88-577	USDA-FS
Pecos Wild.	NM	167,416	88-577	USDA-FS
Salt Creek Wild.	NM	8,500	91-504	USDI-FWS
San Pedro Parks Wild.	NM	41,132	88-577	USDA-FS
Wheeler Peak Wild.	NM	6,027	88-577	USDA-FS
White Mtn. Wild.	NM	31,171	88-577	USDA-FS
Great Smoky Mtns. NP[5]	NC	273,551	69-268	USDI-NPS
Joyce Kilmer-Slickrock Wild.[6]	NC	10,201	93-622	USDA-FS
Linville Gorge Wild.	NC	7,575	88-577	USDA-FS
Shining Rock Wild.	NC	13,350	88-577	USDA-FS
Swanguarter Wild.	NC	9,000	94-557	USDI-FWS
Lostwood Wild.	ND	5,557	93-632	USDI-FWS

TABLE B-1. PSD CLASS I AREAS DESIGNATED UNDER THE CLEAN AIR ACT AMENDMENTS OF 1977 (CONTINUED)

Area names[1]	State	Acreage	Establishing Public Law	Federal Manager
Theodore Roosevelt NMP	ND	69,675	80-38	USDI-NPS
Wichita Mtns. Wild.	OK	8,900	91-504	USDI-FWS
Crater Lake NP	OR	160,290	57-121	USDI-NPS
Diamond Peak Wild.	OR	36,637	88-577	USDA-FS
Eagle Cap Wild.	OR	293,476	88-577	USDA-FS
Gearhart Mtn. Wild.	OR	18,709	88-577	USDA-FS
Hells Canyon Wild.[2]	OR	108,900	94-199	USDA-FS
Kalmiopsis Wild.	OR	76,900	88-577	USDA-FS
Mtn. Lakes Wild.	OR	23,071	88-577	USDA-FS
Mt. Hood Wild.	OR	14,160	88-577	USDA-FS
Mt. Jefferson Wild.	OR	100,208	90-548	USDA-FS
Mt. Washington Wild.	OR	46,116	88-577	USDA-FS
Strawberry Mtn. Wild.	OR	33,003	88-577	USDA-FS
Three Sisters Wild.	OR	199,902	88-577	USDA-FS
Cape Romain Wild.	SC	28,000	93-632	USDI-FWS
Badlands Wild.	SD	64,250	94-567	USDI-NPS
Wind Cave NP	SD	28,060	57-16	USDI-NPS
Great Smoky Mtns. NP[5]	TN	241,207	69-268	USDI-NPS
Joyce Kilmer-Slickrock Wild.[6]	TN	3,832	93-622	USDA-FS
Big Bend NP	TX	708,118	74-157	USDI-NPS
Guadalupe Mtns. NP	TX	76,292	89-667	USDI-NPS
Arches NP	UT	65,098	92-155	USDI-NPS
Bryce Canyon NP	UT	35,832	68-277	USDI-NPS
Canyonlands NP	UT	337,570	88-590	USDI-NPS

TABLE B-1. PSD CLASS I AREAS DESIGNATED UNDER THE CLEAN AIR ACT AMENDMENTS OF 1977 (CONTINUED)

Area names[1]	State	Acreage	Establishing Public Law	Federal Manager
Capitol Reef NP	UT	221,896	92-507	USDI-NPS
Zion NP	UT	142,462	68-83	USDI-NPS
Lyle Brook Wild.	VT	12,430	93-622	USDAFS
Virgin Islands NP	VI	12,295	84-925	USDI-NPS
James River Face Wild.	VA	8,703	93-622	USDA-FS
Shenandoah NP	VA	190,535	69-268	USDI-NPS
Alpine Lakes Wild.	WA	303,508	94-357	USDA-FS
Glacier Peak Wild.	WA	464,258	88-577	USDA-FS
Goat Rocks Wild.	WA	82,680	88-577	USDA-FS
Mount Adams Wild.	WA	32,356	88-577	USDA-FS
Mount Rainier NP	WA	235,239	30 Stat. 993 (55th Cong.)	USDI-NPS
North Cascades NP	WA	503,277	90-554	USDI-NPS
Olympic NP	WA	892,578	75-778	USDI-NPS
Pasayten Wild.	WA	505,524	90-554	USDA-FS
Dolly Sods Wild.	WV	10,215	93-622	USDA-FS
Otter Creek Wild.	WV	20,000	93-622	USDA-FS
Rainbow Lake Wild.	WI	6,388	93-622	USDA-FS
Bridger Wild.	WY	392,160	88-577	USDA-FS
Fitzpatrick Wild.	WY	191,103	94-567	USDA-FS
Grand Teton NP	WY	305,504	81-787	USDI-NPS
North Absaroka Wild.	WY	351,104	88-577	USDA-FS
Teton Wild.	WY	557,311	88-577	USDA-FS
Washakie Wild.	WY	686,584	92-476	USDA-FS
Yellowstone NP[4]	WY	2,020,625	17 Stat. 32 (42nd Cong.)	USDI-NPS

TABLE B-1. PSD CLASS I AREAS DESIGNATED UNDER THE CLEAN AIR ACT AMENDMENTS OF 1977 (CONTINUED)

Area names[1]	State	Acreage	Establishing Public Law	Federal Manager

Area Name	Province	Acreage	Applicable U.S. Public Law
Roosevelt Campobello International Park[7]	New Brunswick Canada	2,721	88-363

[1]Wilderness is abbreviated as Wild., National Park and NP, and National Memorial Park as NMP.

[2]Hells Canyon Wilderness, 193,840 acres overall, of which 108,900 acres are in Oregon and 83,800 acres are in Idaho.

[3]Selway Bitterroot Wilderness, 1,240,618 acres overall, of which 988,770 acres are in Idaho and 25,930 acres are in Montana.

[4]Yellowstone National Park, 2,219,737 acres overall, of which 2,020,625 acres are in Wyoming, 167,624 acres are in Montana, and 31,488 acres are in Idaho.

[5]Great Smoky Mountains National Park, 514,577 acres overall, of which 273,551 acres are in North Carolina, and 241,207 acres are in Tennessee.

[6]Joyce Kilmer-Slickrock Wilderness, 14,033 acres overall, of which 10,201 acres are in North Carolina, and 3,832 acres are in Tennessee.

[7]Section 162(a) designates all international parks as mandatory Class I areas. This designation indicates Congressional intent to prevent visibility impairment from U.S. air pollution sources.

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APPENDIX C

MAILS DISPERSION MODEL FORTRAN CODE

```
$INCLUDE: 'FOREXEC.INC'
C   MULTIPLE AIRCRAFT INSTANTANEOUS LINE SOURCE (MAILS) MODEL
C          VERSION: 1.1, DATED 2/15/90
C
C          AUTHORS:  EDWARD LIEBSCH, RESEARCH ASSOCIATE,
C                        (615-574-2702)
C                    R.D. SHARP, COMPUTING SPECIALIST II
C                        (615-576-2308)
C
C                    OAK RIDGE NATIONAL LABORATORY
C                    OPERATED BY MARTIN MARIETTA ENERGY SYSTEMS, INC.
C                    P.O. BOX 2008
C                    OAK RIDGE, TN. 37831
C
C
      CHARACTER*6 AIRC
      DIMENSION ISTAB(49),WS(49),ARR(49),SC(6),SD(6)
      DIMENSION AIRC(16),AS(16),QPRIME(16),RHT(16),IFR(5,16),CMAX(16)
      CHARACTER*70 TITLE
      CHARACTER*4 POLU
      CHARACTER*1 CHAR,STAND,PRDEST
      CHARACTER*12 FNAME
C
C
      DATA ISTAB / 7*1,9*2,9*3,14*4,5*5,5*6 /
      DATA WS / 0.5,0.8,1.0,1.5,2.0,2.5,3.0,0.5,0.8,1.0,1.5,2.0,2.5,3.0,
     14.0,5.0,2.0,2.5,3.0,4.0,5.0,7.0,10.0,12.0,15.0,0.5,0.8,1.0,1.5,2.0
     2,2.5,3.,3.,5.,7.,10.,12.,15.,20.,2.,2.5,3.,4.,5.,2.,2.5,3.,4.,5. /
      DATA SC,SD / 24.1667,18.333,12.5,8.333,6.25,4.1667,2.5334,1.8096,
     1 1.0857,.72382,.54287,.36191 /
C
      OPEN (UNIT=8,FILE = 'SAILS.OUT')
      OPEN(UNIT=1,FILE='MODEL.DAT')
      OPEN(UNIT=2,FILE='TITLE.DAT')
C
C   *************  DATA FILE TITLE.DAT CONTAINS A HEADER RECORD (A70) **
      READ(2,801) TITLE
C   *******************************************************************
C
C   ************** INPUT DATA (MODEL.DAT) ******************************
C     AIRC(i)   = AIRCRAFT i IDENTIFIER  (LE 6 CHARACTERS)
C     AS(i)     = THE AIRSPEED OF AIRCRAFT i (MPH)
C     QPRIME(i) = THE RELEASE RATE OF POLLUTANT (LB/HR) FROM AIRCRAFT i
C     RHT(i)    = THE RELEASE HEIGHT (FT) OF POLLUTANT FROM AIRCRAFT i
C     AMH       = THE SURFACE MIXING (INVERSION) HEIGHT (FT)
C         THE INVERSION HEIGHT MUST BE GREATER THAN THE RELEASE HEIGHT
C         OR THE GROUND-LEVEL CONCENTRATION IS ASSUMED TO BE NEGLIGIBLE.
C         PROGRAM STOPS WITH CODE 1111 IF A VALUE LESS THAN OR EQUAL TO
C         THE RELEASE HEIGHT HAS BEEN ENTERED.
C     IFR(k,i)  = FREQUENCY OF FLIGHTS FOR AIRCRAFT i FOR TIME PERIOD k
C                 k=1(1-HR), k=2(3-HR), k=3(8-HR), k=4(24-HR), k=5(AN.)
C     POLU      = POLLUTANT NAME: SO2 ,NO2 ,PART, OR CO (4 CHARACTERS)
C     STAND     = STANDARDS RUN FLAG: S MEANS TO COMPARE CONCENTRATIONS
C                     AGAINST STANDARD PSD (NAAQS FOR 1,8-HR) INCREMENTS
C     PRDEST    = FLAG FOR PRINT DESTINATION: P MEANS TO WRITE THE CONC.
C                     TABLE TO THE PRINTER, AND TO FILE MODEL.PRT
C     PRDEST    =                           F MEANS TO WRITE THE CONC.
C                     TABLE TO FILE FNAME (SEE NEXT VARIABLE DEFINITION)
C     FNAME     = FILE NAME (LE 12 CHARACTERS) TO WHICH THE CONC. TABLE
C                     IS WRITTEN IF PRDEST=F
```

```
C     *********************************************************************
C
        I=0
      1 I=I+1
        READ(1,802,END=15)AIRC(I),AS(I),QPRIME(I),RHT(I),AMH,(IFR(K,I),
     1      K=1,5),POLU,STAND,PRDEST,FNAME
        IF(RHT(I).GE.AMH)THEN
         WRITE(*,803)RHT(I),AMH,I
         STOP 1111
        END IF
        IF(I.EQ.1)THEN
         AMHFT=AMH
         IF(PRDEST.EQ.'F')THEN
          OPEN(UNIT=9,FILE=FNAME)
          WRITE(*,'('' Results from MAILS are written to file:'',
     1    2X,A12,/)')FNAME
         ELSE
          OPEN(UNIT=9,FILE='MODEL.PRT')
          WRITE(*,'('' Results from MAILS are written to file:'',
     1    2X,''MODEL.PRT'',/)')
         END IF
        END IF
        GO TO 1
     15 NUMAC=I-1
        WRITE(8,804)
        DO 310 IA=1,NUMAC
        IF(IA.EQ.1)THEN
         WRITE(8,805) TITLE
        ELSE
         WRITE(8,806)CHAR(12),TITLE
        END IF
        WRITE(8,807) AIRC(IA),RHT(IA),AMHFT,QPRIME(IA),AS(IA)
        WRITE(*,808)AIRC(IA)
C     SPECIFY PORTION OF LINE SOURCE TO BE MODELED AS A DISCRETE PUFF
C     IN UNITS OF METERS.
        PL = 100.
C     CONVERT AIRCRAFT AIRSPEED FROM MILES/HR. TO METERS/SEC.
        ASM = AS(IA)*0.447
C     CONVERT RELEASE HEIGHT AND MIXING HEIGHT FROM FEET TO METERS
        RHT(IA) = RHT(IA)*0.3048
        AMH = AMHFT*0.3048
        AMHI = 1.0/AMH
C     CONVERT EMISSION RATE FROM LB/HR TO GRAMS/SEC
        QPRIME(IA) = QPRIME(IA)*0.126
C     COMPUTE THE MASS OF ONE PUFF IN GRAMS
        Q = QPRIME(IA)*PL/ASM
C     BEGIN LOOP OVER ALL STABILITY/WIND SPEED COMBINATIONS
        DO 200 I=1,49
C     COMPUTE THE NUMBER OF PUFFS WHICH PASS A CENTERLINE RECEPTOR
C     IN A ONE-HOUR PERIOD
        NPUFF = WS(I)*3600./PL + 0.5
        UBARI = 1.0/WS(I)
        X = 0.0
        SPSI = 0.0
        IST = ISTAB(I)
C     BEGIN LOOP OVER PUFFS
        DO 100 J=1,NPUFF
        PX = J - 0.5
        X = PL*PX
        XK = .001*X
```

```
C   COMPUTE SIGMA-Y
      TH = .017453293*(SC(IST)-SD(IST)*ALOG(XK))
      SIGY = 465.11628*XK*TAN(TH)
      SIGYI = 1.0/SIGY
C   CALL SUBROUTINE TO COMPUTE SIGMA-Z
      CALL SIGMAZ(XK,SZ,IST)
      SIGZI = 1.0/SZ
C   CHECK IF SIGMA-Z IS LARGE COMPARED TO MIXING HEIGHT
C   IF SO, ASSUME UNIFORM VERTICAL MIXING
C
      IF(SZ .GE. 1.6*AMH) GOTO 50
C   CALCULATE VERTICAL TERM (V)
      V = 0.0
      A2 = 0.0
   40 VL = V
      A2 = A2 + 2.0
      HMA2 = A2*AMH
      A3 = (HMA2-RHT(IA))*SIGZI
      A4 = (HMA2+RHT(IA))*SIGZI
      A3  = -.5*A3*A3
      A4 = -.5*A4*A4
      A5 = 0.0
      IF(A3 .GT. -38.) A5 = EXP(A3)
      A6 = 0.0
      IF(A4 .GT. -38.) A6 = EXP(A4)
      V = V + A5 + A6
      IF(ABS(V-VL) .GT. 1.E-8) GOTO 40
      A2 = -.5*RHT(IA)*RHT(IA)*SIGZI*SIGZI
      IF(A2 .GT. -38.) V = EXP(A2) + V
C   EQUATION FOR TOTAL EXPOSURE FROM AN INSTANTANEOUS PUFF RELEASE
      PSI = .318309886*Q*SIGYI*SIGZI*UBARI*V
      GOTO 90
C   EQUATION FOR TOTAL EXPOSURE FROM AN INSTANTANEOUS PUFF RELEASE WITH
C   UNIFORM VERTICAL MIXING
   50 PSI = Q*SIGYI*AMHI*UBARI*.39894228
C
C   SUM EXPOSURE FOR PUFF AND GET ANOTHER PUFF
   90 SPSI = SPSI + PSI
  100 CONTINUE
C
C   CONVERT ONE-HOUR EXPOSURE TO A ONE-HOUR CONCENTRATION
      CHI = SPSI/3600.0
      ARR(I) = CHI
  200 CONTINUE
C
C  WRITE OUTPUT TO FILE
      WRITE(8,809)
      ISTOLD = 1
      DO 300 I=1,49
      IF(ISTAB(I) .NE. ISTOLD) WRITE(8,810)
      WRITE(8,811) ISTAB(I),WS(I),ARR(I)
      CMAX(IA)=AMAX1(CMAX(IA),ARR(I))
      ISTOLD = ISTAB(I)
  300 CONTINUE
  310 CONTINUE
      CALL OUTPUT(AIRC,AS,QPRIME,RHT,AMHFT,IFR,CMAX,NUMAC,POLU,STAND,
     1            PRDEST,TITLE)
      STOP
C
C
```

```
  801 FORMAT(A70)
  802 FORMAT(A6,F3.0,F8.0,F5.0,F5.0,4I3,I4,A4,A1,A1,A12)
  803  FORMAT(' The specified RELEASE HEIGHT ',F6.0,' is higher than the
     1 MIXING HEIGHT ',F7.0,/,'       for AIRCRAFT #',I3)
  804 FORMAT(25X,'MAILS - VERSION 1.1 (2/15/90)',/,25X,'MULTIPLE AIRCRAF
     1T INSTANTANEOUS',/,25X,'LINE SOURCE MODEL',///)
  805 FORMAT(32X,'**** TITLE ****',//,A70,//)
  806 FORMAT(A1,32X,'**** TITLE ****',//,A70,//)
  807 FORMAT(' INPUT DATA FOR AIRCRAFT ',A6,
     <       /' ----------',14X,'------',/,' RELEASE HEIGHT    =',F10.3
     1,' FEET',/,' INVERSION HEIGHT  =',F10.3,' FEET',/,' EMISSION RATE
     2     =',F10.3,' LB/HR',/,' AIRCRAFT AIRSPEED =',F10.3,' MILES/HR'//
     3/)
  808 FORMAT(' EXECUTION CONTINUING...... FOR AIRCRAFT ',A6)
  809 FORMAT(11X,'STABILITY',6X,'WIND SPEED',5X,'ONE-HR. CONC.',/,27X,'(
     1M/SEC.)',6X,'(GRAMS/M**3)')
  810 FORMAT(' ')
  811 FORMAT(14X,I2,11X,F6.2,8X,E11.4)
      END
C
C   SUBROUTINE SIGMAZ CALCULATES THE VERTICAL STANDARD DEVIATION OF
C   THE PUFF CONCENTRATION DISTRIBUTION.  THE COEFFICIENTS WERE TAKEN
C   FROM THE EPA ISCST MODEL (DATED 88207).
C
      SUBROUTINE SIGMAZ(X,SZ,IST)
      DIMENSION SASIGZ(38),SBSIGZ(38),X1(10,6),INDSGZ(6)
      DATA SASIGZ / 122.8,
     1              158.08,170.22,179.52,217.41,258.89,346.75,2*453.85,
     2 90.673,98.483,109.3,61.141,34.459,32.093,32.093,33.504,36.65,
     3  44.053,24.26,
     4          23.331,21.628,21.628,22.534,24.703,26.97,35.42,47.61,
     5 15.209,14.457,13.953,13.953,14.823,16.187,17.836,22.651,27.074,
     6 34.219 /
      DATA SBSIGZ /.9447,
     X              1.0542,1.0932,1.1262,1.2644,1.4094,1.7283,2*2.1166,
     1 .93198,.98332,1.0971,.91465,.86974,.81066,.64403,.60486,.56589,
     X  .51179,.8366,
     2          .81956,.75660,.63077,.57154,.50527,.46713,.37615,.29592,
     3 .81558,.78407,.68465,.63227,.54503,.46490,.41507,.32681,.27436,
     4 .21716 /
      DATA INDSGZ /0,9,12,13,19,28/
      DATA X1 /.1,.15,.2,.25,.3,.4,.5,3.11,1.E20,0.,  .2,.4,1.E20,7*0.,
     1 1.E20,9*0.,  .3,1.,3.,10.,30.,1.E20,4*0.,  .1,.3,1.,2.,4.,10.,
     2 20.,40.,1.E20,0.,  .2,.7,1.,2.,3.,7.,15.,30.,60.,1.E20/
C
      I = 1
      IF(IST .EQ. 3) GOTO 20
   10 IF(X-X1(I,IST) .LE. 0.0) GOTO 20
      I = I + 1
      GOTO 10
   20 INDX1 = INDSGZ(IST) + I
      SZ = SASIGZ(INDX1)*X**SBSIGZ(INDX1)
      SZ = AMIN1(SZ,5000.)
      RETURN
      END
      SUBROUTINE OUTPUT(AIRC,AS,QPRIME,RHT,AMH,IFR,CMAX,NUMAC,POLU,
     1                  STAND,PRDEST,TITLE)
      INTEGER*2 SYSTEM
      CHARACTER*70 TITLE
      CHARACTER ANS
```

```
      CHARACTER*6 AIRC
      CHARACTER*7 AVT(5)
      CHARACTER STAND,CHAR,PRDEST
      CHARACTER*4 POLU
      DIMENSION AIRC(16),AS(16),QPRIME(16),RHT(16),IFR(5,16),CMAX(16)
      DIMENSION PSD(3,4),KNTA(4),ITM(3,4),DIV(5),SFACT(5),NTP(5)
      DATA AVT/'1-hour ','3-hour ','8-hour ','24-hour','Annual '/
C     PSD(IT,IP) = PSD CLASS 1 INCREMENTS (micrograms/m**3)
C       IP=1 FOR NO,IP=2 FOR SO2, IP=3 FOR PART, IP=4 FOR CO
C            IT=1 FOR 1-HR, IT=2 FOR 3-HR, IT=3 FOR 8-HR, IT=4 FOR 24-HR
C        AND IT=5 FOR Annual
C       NOTE: FOR CO, PSD(1,4)= NAAQS 1-HR STANDARD,
C                     PSD(2,4)= NAAQS 8-HR STANDARD
C         -999. MEANS NO VALUE ASSIGNED (NA)
      DATA PSD/2.5,-999.,-999.,  25.,5.,2.,  8.,4.,-999.,
     1         40000.,10000.,-999./
      DATA KNTA/1,3,2,2/
      DATA ITM/5,0,0, 2,4,5, 4,5,0, 1,3,0/
      DATA NTP/5*0/
      DATA SFACT/1.0,0.5,0.33,0.25,0.1/
      DATA DIV/1.0,3.0,8.0,24.0,8760.0/
      WRITE(9,800)
      IF(POLU.EQ.'NO2 ')IP=1
      IF(POLU.EQ.'SO2 ')IP=2
      IF(POLU.EQ.'PART')IP=3
      IF(POLU.EQ.'CO  ')IP=4
      IAMH=IFIX(AMH+.5)
      IF(STAND.EQ.'S')THEN
       NUMT=KNTA(IP)
       NLTAB=15
      ELSE
       NUMT=5
       NLTAB=12
      END IF
        DO 5 NTAB=1,NUMT
        IF(NTAB.EQ.1)CALL TABLEC(NUMT,NLTAB,NUMAC,NTP)
        IF(NTP(NTAB).EQ.1.AND.NTAB.NE.1)THEN
         WRITE(9,8001)CHAR(12),TITLE
        ELSE
         WRITE(9,801)TITLE
        END IF
        WRITE(9,802)POLU,NUMAC
        IF(STAND.EQ.'S')THEN
         K=ITM(NTAB,IP)
        ELSE
         K=NTAB
        END IF
        WRITE(9,803)AVT(K),IAMH
        WRITE(9,804)AVT(K)
        WRITE(9,805)
        WRITE(9,806)
        CT=0.0
        DO 10 IA=1,NUMAC
C       TO PRINT PARAMETERS AS INTEGERS
        IRHT=IFIX(RHT(IA)/.3048+.5)
        IAS=IFIX(AS(IA)+.5)
        QP=QPRIME(IA)/.126
C       CONCENTRATION UNIT OF C IS MICROGRAMS
        C=((CMAX(IA)*FLOAT(IFR(K,IA)))/DIV(K))*SFACT(K)*1.0E+6
        CT=CT+C
```

```
          IF(C.GE.1.0E-4)THEN
           WRITE(9,807)AIRC(IA),IRHT,IAS,QP,IFR(K,IA),C
          ELSE
           WRITE(9,808)AIRC(IA),IRHT,IAS,QP,IFR(K,IA),C
          END IF
 10       CONTINUE
         WRITE(9,809)
         IF(CT.GE.1.0E-4)THEN
          IF(AVT(K).NE.'Annual')WRITE(9,810)AVT(K),CT
          IF(AVT(K).EQ.'Annual')WRITE(9,811)CT
         ELSE
          IF(AVT(K).NE.'Annual')WRITE(9,812)AVT(K),CT
          IF(AVT(K).EQ.'Annual')WRITE(9,813)CT
         END IF
         IF(STAND.EQ.'S')THEN
          PERC=CT/PSD(NTAB,IP)*100.
          IPERC=IFIX(PSD(NTAB,IP))
          IF(PERC.GE.0.01)THEN
           IF(AVT(K).NE.'Annual')WRITE(9,814)AVT(K),PERC,AVT(K),POLU,IPERC
           IF(AVT(K).EQ.'Annual')WRITE(9,816)PERC,POLU,IPERC
          ELSE
           IF(AVT(K).NE.'Annual')WRITE(9,815)AVT(K),PERC,AVT(K),POLU,IPERC
           IF(AVT(K).EQ.'Annual')WRITE(9,817)PERC,POLU,IPERC
          END IF
         END IF
  5 CONTINUE
800 FORMAT('MAILS - VERSION 1.1 (2/15/90): MULTIPLE AIRCRAFT INSTANTAN
   1EOUS LINE SOURCE MODEL')
801   FORMAT(//,A70,' *********',/)
802   FORMAT(1X,'Pollutant  :  ',A4,T30,'No. of Aircraft (Types) :  ',
  1    I5)
803   FORMAT(1X,'Avg. Period:  ',A7,T30,'Mixing Height            :  ',
  1   I5,' ft.',/)
804 FORMAT('Aircraft',3X,'Altitude',3X,'Airspeed',2X,'Emiss. Rate',2X,
  1        'Flight',4X,A7,' Conc.')
805 FORMAT(T13,'(ft)',T24,'(mph)',T35,'(lb/hr)',T46,'Freq.',T59,
  1          'Conc.',T54,'(micrograms/m**3)')
806   FORMAT('--------',T12,'--------',T23,'--------',T33,'-----------
  1',T46,'------',T54,'-----------------')
807   FORMAT(2X,A6,I8,3X,I8,6X,0PF8.2,5X,I4,7X,0PF8.4)
808   FORMAT(2X,A6,I8,3X,I8,6X,0PF8.2,5X,I4,7X,1PE8.2)
809  FORMAT(T54,'-----------------')
810  FORMAT(T33,'Total ',A7,' conc. =    ',0PF8.4)
811  FORMAT(T33,'Total annual conc.  =    ',0PF8.4)
812  FORMAT(T33,'Total ',A7,' conc. =    ',1PE8.2)
813  FORMAT(T33,'Total annual conc.  =    ',1PE8.2)
814  FORMAT(/,9X,'The total ',A7,' conc. is ',F8.4,' %',' of the PSD',
   < /,
   1 4X,'Class I ',A7,' increment for ',A4,'(',I5,' micrograms/m**3)')
815  FORMAT(/,9X,'The total ',A7,' conc. is ',1PE8.2,' %',' of the PSD
   <',/,
   1 4X,'Class I ',A7,' increment for ',A4,'(',I5,' micrograms/m**3)')
816  FORMAT(/,9X,'The total annual conc. is ',F8.4,' %',' of the PSD',
   < /,
   1 4X,'Class I annual increment for ',A4,'(',I5,' micrograms/m**3)')
817  FORMAT(/,9X,'The total annual conc. is ',1PE8.2,' %',' of the PSD
   <',/,
   1 4X,'Class I annual increment for ',A4,'(',I5,' micrograms/m**3)')
8001 FORMAT(A1,A70,' *********',/)
     CLOSE(UNIT=9)
```

```
C     *******************  PRINT THE RESULT FILE ?  *******************
        IF(PRDEST.EQ.'P')THEN
         WRITE(*,'(//,'' Is the PRINTER (LPT1) ready: Y or N?  '')')
         READ(*,'(A1)')ANS
         IF(ANS.EQ.'Y'.OR.ANS.EQ.'y')THEN
          I=SYSTEM('PRINT MODEL.PRT'C)
         ELSE
          I=SYSTEM('CLS'C)
          WRITE(*,'(//,'' Result file MODEL.PRT cannot be printed by this
     1program'',/,14X,''until LPT1 is ready!  '')')
          WRITE(*,'('' Hit ENTER to continue.  '')')
          READ(*,'(A1)')ANS
         END IF
        END IF
C     ****************************************************************
        RETURN
        END
        SUBROUTINE TABLEC(NUMT,NLTAB,NUMAC,NTP)
        DIMENSION NTP(5)
C       NTP(i) IS INDICATOR THAT TABLE i BEGINS AT THE TOP OF A NEW PAGE
        NLPAGE=60
        IT=0
        NLPB=0
      1 IT=IT+1
        IF(IT.GT.NUMT)GO TO 10
        NLP=NLTAB+NUMAC+(6-IT)/5+NLPB
        IF(NLP.LE.NLPAGE)THEN
         NLPB=NLP
         GO TO 1
        ELSE
         NTP(IT)=1
         NLPB=NLTAB+NUMAC
         GO TO 1
        END IF
     10 CONTINUE
        RETURN
        END
```


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APPENDIX D

THE MULTIPLE AIRCRAFT INSTANTANEOUS LINE SOURCE MODEL (MAILS)

BACKGROUND

Low-altitude flight operations are a critical ingredient in maintaining a well-trained, combat ready Air Force. However, operations along military training routes (MTRs), due to their proximity to the surface and repetitive flights within a relatively narrow corridor, often raise community concerns regarding adverse effects on visibility, noise levels, and air pollutant concentrations. Such concerns may result in restrictions on acquisition and use of airspace, with a negative impact on effective training operations. Thorough, defensible environmental impact documentation addresses such concerns, and provides for compliance with legislation such as the National Environmental Policy Act (NEPA). Guidance and direction for preparing environmental documentation regarding Air Force operations is provide by AFR 19-2, USAF Environmental Impact Analysis Process (EIAP). The purpose of the MAILS model is to support the EIAP regarding air quality impact of operations along MTRs. It was developed to fill the gap between simple lookup tables from which total emissions along an MTR could be estimated, and complex dispersion models requiring considerable time and effort in terms of data gathering, input, and post-processing for applicability to MTR scenarios.

MAILS

The MAILS model itself is an interactive air quality screening tool that combines a military aircraft engine emissions database with a gaussian puff dispersion model. MAILS operates on IBM-compatible PC-AT, 386, or 486 microcomputers with DOS version 3.0 or later. The model requires 360 Kb available RAM, can take advantage of a math coprocessor if one is available, and should normally be installed on and run from a hard disk.

AIRCRAFT EMISSIONS DATABASE

The MAILS emissions database contains information for roughly 50 military aircraft types. For each aircraft, the database includes the following information: airspeed, fuel rate (per engine), emission factor (pounds pollutant per pound fuel burned), number of engines, emissions flag (a reference describing where emissions data for the aircraft was obtained), and total emission rate (fuel rate x emissions factor x number of engines). Emissions data is provided for five pollutants (sulfur dioxide, nitrogen dioxide, particulate matter, carbon monoxide, and hydrocarbons), and is easily updated by the user should new information become available or for application to special cases.

DISPERSION MODEL

The dispersion modeling portion of MAILS utilizes a gaussian puff dispersion model, approximating a line source by dividing the emitted plume into puffs, each with pollutant mass equal to that emitted during a 100 meter segment of the flight path. Ground level concentrations at plume centerline are based on summing the contributions of all puffs that pass over a fixed receptor during a one-hour time period. Consistent with the screening approach taken by MAILS, the ambient wind is assumed parallel to the flight track and homogeneous in space and time. In addition, a matrix of 49 wind speed/atmospheric stability conditions are used to calculate possible concentrations at the receptor, from which the highest is selected for reporting. Note that the same 49 atmospheric conditions are those used in the EPA-approved screening model PTPLU, and that the dispersion coefficients are equal to those used in the EPA ISCST model ("rural" mode coefficients are used, since MTRs rarely pass over urban areas). Multiple aircraft passes within one hour are simply summed together. Multiple passes over longer time periods are summed and then adjusted according to the requested averaging time. MAILS may be used to estimate 1-hour, 3-hour, 8-hour, and 24-hour, and annual concentration averages. Adjustment factors for periods greater than one hour account for variations in meteorological conditions and in flight track positions relative to the stated flight centerline location, and for the intermittent nature of operations along MTRs.

INPUTS/OUTPUTS

The user is required to input the aircraft type(s), pollutant(s) of interest, flight altitude(s), frequency of overflights of a given ground location during the period of interest, and the height of the surface-based temperature inversion (if applicable). The user is also given default values of airspeed, and emission rate, which he may be adjusted to fit any special circumstances. The model provides output (to printer or file) in the form of a table detailing the component of total concentration due to each aircraft type on a given route and the total concentration of each pollutant type, both as an absolute value (micrograms/cubic meter) and as a percentage of NAAQS and PSD Class I standards. Generally, if MTR emissions result in ground level concentrations less than 5 percent of the PSD Class I limits, the screening analysis may be considered to demonstrate negligible impact and no further analysis is necessary. This is usually the case for MTR operations.

VERIFICATION

Because data sets addressing the unique characteristics of MTR ground concentrations as modeled in MAILS do not exist, MAILS' performance has been tested by comparison with an EPA guideline model. The Industrial Source Complex - Short Term (ISCST) model and the MAILS dispersion code were run for emissions at the same height and rate, and under a varied set of meteorological conditions. The results differed by less than 5 percent in all cases. Note that configuring ISCST for application to an elevated, moving line source, and inputting required aircraft engine emissions data is a laborious

and time consuming process, one of the primary reasons for MAILS' development. Details of the model comparison are available in the MAILS user's guide (ESL-TR-89-59).

ADVANTAGES OF MAILS

MAILS offers several advantages over previous methods of screening for air quality impact along training routes. It combines emissions data, aircraft configuration data, and dispersion code into one user-friendly software package. It is optimized to provide ground track concentration estimates below training routes, where previous models required laborious adaptation to this purpose. The MAILS database is readily updated as new aircraft types and engine models enter the operational inventory. The output from MAILS is given in terms which allow quick comparison to regulatory standards. Where assumptions have been made in the dispersion model, these have generally been of a conservative nature, such that the model is unlikely to underpredict pollutant concentrations. An indication of negligible impact by the model thus has a high degree of confidence.

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